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JOURNAL of PALEONTOLOGY

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VOLUME 13 MARCH, 1939 NUMBER 2

AN AMMONOID FAUNA FROM THE LOWER PENNSYLVANIAN CHEROKEE FORMATION OF MISSOURI

A. K. MILLER AND JOHN BRITTS OWEN

ABSTRACT—Intensive collecting in the Cherokee formation of Henry County, Missouri, and adjacent regions has yielded in abundance well-preserved representatives of nine ammonoid species, belonging in eight genera. These are illustrated and described in this report. The genus *Anthracoceras* has been found in Missouri at only one horizon, about 10 to 15 feet below the Jordan coal member of the Cherokee formation. *Glaphyrites*, *Bisatoceras*, and *Goniolobоceras* are represented in the beds which immediately overlie both the Tebo and the Mulky coal members of the Cherokee, and in addition *Bactrites*, *Imitoceras*, *Neoglyphioceras*, and *Dimorphoceras* have been found just above the Mulky coal. Illustrations and a description of a new species of *Anthracoceras* from the Boggy shale of Oklahoma are included. The conclusion is reached that the ammonoid fauna of the beds just above the Mulky coal is probably of about the same age as that which occurs in the Wigton shale of England and in Skipsey's marine band of Scotland.

THE Cherokee is the lowest formation of the Pennsylvanian system in the northern portion of the Mid-Continent region. In Missouri its thickness varies from about 350 to 700 feet (Greene, 1933, p. 15). Lithologically the formation consists predominantly of shale, but there is a great deal of variation both vertically and laterally within it. It contains considerable quantities of sandstone and some limestone, and coal beds are scattered throughout its entire vertical and horizontal extent. In all but the lower portions of the formation, the limestone and coal members are fairly continuous over large areas, and they are therefore good horizon markers. The coal beds are of very great economic importance, and in southern Kansas and adjacent parts of Oklahoma the more or less irregular beds of sandstone in the Cherokee have yielded considerable quantities of oil and gas. The accompanying diagram (text figure 1) portrays the general nature of the Cherokee in west-central Missouri.

The Cherokee is not as abundantly fossiliferous as are some of the divisions of the Pennsylvanian system in the Mid-Continent region. However, a few of the beds, particularly certain calcareous horizons, contain numerous marine invertebrates, and other beds (generally associated with coal) yield remains of land plants. Cephalopods are not as abundant in the northern part of the Mid-Continent region as they are farther south, and the large collection which we are studying represents the results of fifteen years of patient, intensive collecting in west-central Missouri in and around the numerous strip-pits that are dug to obtain coal—only a very few of the specimens came from natural exposures. Most of them came from large black calcareous nodules or concretions which occur in the shales that immediately overlie the Tebo and Mulky coals; the shales that surround these nodules are also fossiliferous, but the fossils in them are so fragile that it is rarely possible to collect good specimens.

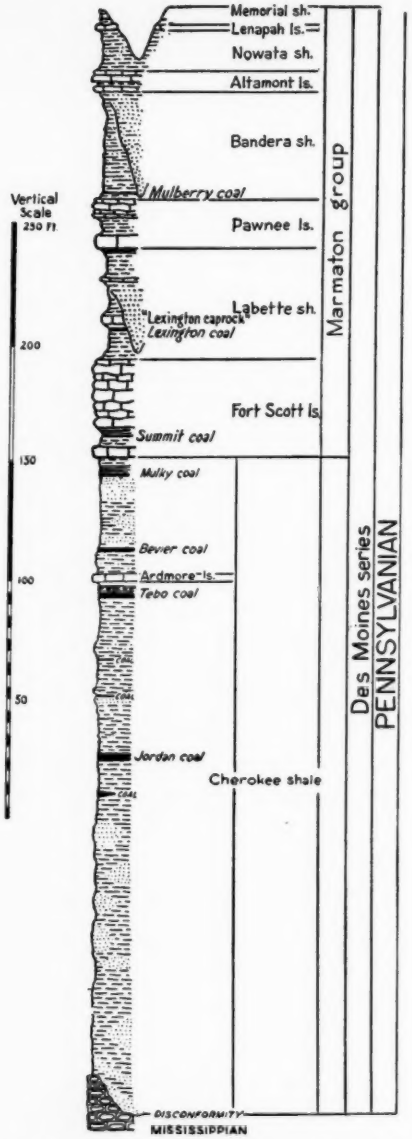


FIG. 1.—Diagram showing the general nature of the Cherokee formation and adjacent beds in west-central Missouri. (After R. C. Moore, 1936; beds above Cherokee, R. C. Moore, and J. M. Jewett, 1938.)

In Henry County, Missouri, whence came the great majority of the specimens we are studying, there are six fossiliferous horizons or zones in the Cherokee. These are: (1) beds 10 to 15 feet below the Jordan coal, (2) the blue shale that immediately overlies the Jordan coal, (3) the slabby "ironstone" immediately above the blue shale just mentioned, (4) calcareous nodules or concretions in the beds just above the Tebo coal, (5) a 2-foot limestone member close to the horizon of the Bevier coal, and (6) the beds immediately above the Mulky coal.

From the first of these six zones we obtained the types and only known specimens of *Anthracoceras missouriense* Miller and Owen, n. sp., and representatives of the following nautiloid species:

Mooreoceras normale Miller, Dunbar and Condra
Bactrites? cherokeensis Miller and Owen
Ephippioceras ferratum (Cox)
Megaglossoceras pristinum Miller and Owen
Metacoceras mutabile Miller and Owen
Domatoceras williamsi Miller and Owen
Solenochilus peculiare Miller and Owen

Three of these nautiloid species (*Bactrites? cherokeensis*, *Megaglossoceras pristinum*, and *Solenochilus peculiare*) are not known to occur except at this horizon, but only one representative of each of the three has so far been found.

The blue shale immediately above the Jordan coal has yielded many types of fossil plants and some marine invertebrates. In 1899 David White published illustrations and descriptions of the flora, and in 1915 he revised his conclusions as to the age of the containing beds. We have never been able to find ammonoids at this horizon, but Girty (1915, p. 364) lists *Glaphyrites welleri* (Smith) from it.

The third zone is only about 4 to 6 inches thick. No ammonoids are known from it, but we have found some fragmentary nautiloids here. All of these are referable to the genus *Metacoceras*, but they represent more than one species.

The concretions immediately above the Tebo coal constitute the most abundantly fossiliferous zone in the Henry County Cherokee. These concretions have yielded representatives of the following four species of ammonoids and fourteen species and varieties of nautiloids:

Glaphyrites welleri (Smith)
Glaphyrites moorei Miller and Owen, n.sp.
Bisatoceras greenei Miller and Owen, n. sp.

Goniloboceras eliasi Miller and Owen, n. sp.
Pseudorthoceras knoxense (McChesney)
Poterioceras bransoni Miller and Owen
Mooreoceras normale Miller, Dunbar and Condra
Mooreoceras normale uniconstrictum Miller and Owen
Brachycycloceras longulum Miller and Owen
Ephippioceras ferratum (Cox)
Coloceras sp.
Knightoceras missouriense Miller and Owen
Temnocheilus harneri Miller and Owen
Metacoceras mutabile Miller and Owen
Metacoceras biseriatum Miller and Owen
Metacoceras sp.
Endolobus sp.
Domatoceras williamsi Miller and Owen

The 2-foot limestone which constitutes the fifth fossiliferous zone of the Henry County Cherokee has not yielded any cephalopods. However, it contains small gastropods in abundance, and J. B. Knight has written us that it is close to the horizon of the Bevier coal.

The sixth and last (uppermost) zone lies just above the Mulky coal, and it contains one of the most abundant and varied cephalopod faunas known from the Late Paleozoic of the northern Mid-Continent region. In our report on the Cherokee nautiloids of this region (Miller and Owen, 1934), we followed Hinds and Greene's generalized section of the Cherokee in Henry County, and called the uppermost coal in the Cherokee the Lexington—we now recognize that this coal is the Mulky. From this Mulky horizon we have obtained representatives of the following seven species of ammonoids and thirteen species and varieties of nautiloids:

Bactrites sp.
Imitoceras cherokeense Miller and Owen, n. sp.
Glaphyrites welleri (Smith)
Neoglyphioceras bellilineatum Miller and Owen, n. sp.
Bisatoceras greenei Miller and Owen, n. sp.
Goniloboceras eliasi Miller and Owen, n. sp.
Dimorphoceras politum (Shumard)
Poterioceras bransoni Miller and Owen
Poterioceras mehli Miller and Owen
Mooreoceras normale Miller, Dunbar and Condra
Brachycycloceras longulum Miller and Owen
Coloceras sp.
Temnocheilus sp.
Metacoceras mutabile Miller and Owen
Metacoceras biseriatum Miller and Owen
Parametacoceras bellatulum Miller and Owen
Parametacoceras? crassum (Hyatt)
Endolobus depressus (Hyatt)
Domatoceras umbilicatum Hyatt
Solenochilus newloni (Hyatt)

In 1915 Girty (pp. 270–271, 364, 374) recorded the occurrence of this Mulky cephalopod fauna in black limestone concretions, 3 miles southeast of Higginsville, Lafayette County, Missouri. He believed that the rocks in which it occurs there were probably part of the Fort Scott limestone, but he noted that the fauna is anything but typical of that formation. All three of the species of ammonoids known from this locality (*Glaphyrites welleri*, *Neoglyphioceras bellilineatum*, and *Dimorphoceras politum*) occur elsewhere just above the Mulky coal, and two of them seem to be characteristic of that horizon. The pelecypods which occur at this Higginsville locality also indicate that the fossiliferous rocks there are to be correlated with the beds immediately above the Mulky coal and not the Fort Scott limestone.

Present knowledge in regard to the stratigraphic distribution of ammonoids in the Cherokee of Missouri can be briefly summarized as follows. The lowest horizon at which any cephalopods are known to occur is 10–15 feet below the Jordan coal, approximately in the middle of the formation in west-central Missouri or about 150 feet above the base of the Pennsylvanian in this region. It is important to remember, however, that the oldest Pennsylvanian rocks of Missouri are considerably younger than the basal deposits belonging to this division in some other places. Only one ammonoid species, *Anthracoceras missouriense*, has been found in the fossil zone below the Jordan coal, and insofar as now known it is limited to that horizon. *Glaphyrites welleri*, which has a long range in the

Cherokee, is the only ammonoid species that has been found immediately above the Jordan coal. The beds just above the Tebo coal have yielded four species of ammonoids, *Glaphyrites welleri*, *G. moorei*, *Bisatoceras greenei*, and *Goniolobоceras eliasi*. All but one of these species (*Glaphyrites moorei*) occurs also above the Mulky coal, and that species is so far known to be represented by only one specimen. In addition to three of the Tebo species just listed, four forms, *Bactrites* sp., *Imitoceras cherokeense*, *Neoglyphioceras bellilineatum*, and *Dimorphoceras politum*, are present in the beds immediately above the Mulky coal, in which ammonoids are particularly abundant. Ammonoids are known to occur, then, in four of the six fossiliferous horizons in the Cherokee of Henry County, Missouri. In the lower two of the four horizons in which they occur, ammonoids are rare, but in the upper two they are abundant.

Abernathy has recently (1937) divided the Cherokee of southeastern Kansas into fifteen cyclothems, and Moore (1936, p. 54) has suggested that "there is much to recommend a revision of classification so as to restrict application of Cherokee to beds below the Ardmore limestone." Since abundant and varied ammonoid faunas occur at so few horizons in the Cherokee, it is hardly feasible to subdivide the formation on the basis of them. Insofar as restriction of the term Cherokee to beds below the Ardmore is concerned, evidence from the ammonoids is equivocal. That is, three species of ammonoids are common to the beds just below the Ardmore and those a short distance above the Ardmore (and immediately above the Mulky coal). This fact, of course, militates against the suggested limitation of the term Cherokee. However, in the ammonoid fauna that occurs slightly above the Ardmore (and immediately above the Mulky coal) there are three new forms, *Imitoceras cherokeense*, *Neoglyphioceras bellilineatum*, and *Dimorphoceras politum* (as well as *Bactrites* sp.). Nothing comparable to any of these forms occurs in the Cherokee faunas below the Ardmore, and we are inclined to believe that the addition of these three striking species is more important than the fact that three of their associates occur below the Ardmore.

No ammonoid faunas closely similar to those here described from the Cherokee have so far been found in North America, and only a few more or less isolated specimens are known from equivalent beds. However, it is probably worthy of note that the Cherokee species of *Anthracoceras* is very similar to *A. wanlessi* of the lower Carbondale (just above Coal No. 2) of Illinois, and to *A. oklahomense* (described below) from the Boggy formation of Oklahoma. The strata in which these three species of *Anthracoceras* occur are generally regarded as of about the same age. Also, as was first pointed out by Bisat, Duncan, and Moore (1931), the so-called *Homoceratoides jacksoni* of Skipsey's marine band of Scotland and the Wigton shale of Cumberland, England, appears to be very similar to *Dimorphoceras politum* of the Mulky horizon of the Cherokee, and the two may be conspecific. E. W. J. Moore has written us that J. W. Jackson, after making direct comparisons, stated that the pelecypods which occur in association with *Homoceratoides jacksoni* bear a startling resemblance to those known from just above the Mulky coal in Missouri. These facts, of course, suggest an approximate equivalence of the upper Cherokee with the Wigton shale and Skipsey's marine band.

We wish to acknowledge our indebtedness to Mr. J. P. Harner of Nevada, Mo., who supplied the few Cherokee ammonoids in our collections from Vernon County, Missouri, and Bourbon County, Kansas; to Mr. Howard Webster, who retouched the photographs and inked the line-drawings which accompany this report; to Dr. W. M. Furnish, who aided greatly with the preparation of the illustrations and many portions of the manuscript; and to Mr. Frederick O. Thompson of Des Moines, Iowa, whose generous financial assistance made possible the preparation of this report.

SYSTEMATIC PALEONTOLOGY

BACTRITES sp.

Plate 20, figures 8, 9

Rather small straight slender cephalopods with marginal siphuncles and simple sutures are not rare in the beds immediately above the Mulky coal member of the Cherokee formation. The largest of them in our collec-

tions, which is septate throughout, attains a maximum diameter of about 5½ mm. Another large specimen (pl. 20, fig. 9) is about 50 mm long, though it is not complete adapically or adorally. Apparently the conch was expanded orad very gradually, so that large unbroken specimens would be very long and slender. In cross section the conch is subcircular.

The test is moderately thin and smooth, though on well-preserved specimens traces of fine transverse growth-lines can be discerned. These are not quite directly transverse to the long axis of the conch, but their obliquity may, of course, be due to distortion of the specimen during fossilization. The internal mold also bears transverse lines, and they are very fine and are closely and evenly spaced.

The siphuncle is small and is ventral and marginal in position. The septa are moderately convex apicad. Along the venter each suture appears to form a small tongue-shaped lobe, but otherwise the sutures are almost straight. However, they form slight lateral lobes and similar dorsal and ventro-lateral saddles. The sutures and the growth-lines are not parallel and they cut across one another. The distance between successive sutures seems to vary somewhat during ontogenetic development, but it is always slightly less than the diameter of the conch.

Remarks.—We are uncertain as to whether the above-described specimens are ammonoids or nautiloids, but they appear to be closely related to the genotype of *Bactrites, B. subconicus* Sandberger of the Middle Devonian of Germany. The specific affinities of these specimens are difficult to determine, for there are few characters to which significance can be attached. Presumably they are not very closely related to *Bactrites? cherokeensis* Miller and Owen, which occurs in a considerably lower zone of the Cherokee. The holotype and only known representative of that species is much larger than any of the Henry County specimens under consideration. Both *B. carbonarius* Smith and *B. smithianus* Girty are similar to the specimens we are studying, but their conchs are said to be marked by "wavy, transverse striae," whereas the striae on our specimens are straight.

Occurrence.—All twelve of the specimens in our collections came from just above the Mulky coal member of the Cherokee formation in Henry County, Missouri. They were obtained from the Lear strip pit in sec. 15, T. 43 N., R. 28 W. (pl. 20, fig. 8), the Ewing strip pit in sec. 36, T. 43 N., R. 28 W. (pl. 20, fig. 9), and the Shideler strip pit in sec. 22, T. 43 N., R. 28 W.

Described specimens.—Private collection of John Britts Owen, nos. 620 (pl. 20, fig. 8), 621 (pl. 20, fig. 9), and 622–624.

IMITOCERAS CHEROKEENSE

Miller and Owen, n. sp.

Plate 20, figures 18–20

Conch subglobular and small. The phragmacone of the largest of the syntypes measures only about 4 mm in diameter. The living chamber is at least one-half of a volution in length. Apparently the conch did not get very large (as much as 10 mm in diameter) for apertural lappets are present on some of our specimens, and these, which developed in about one-eighth of a volution, almost certainly were formed only after growth had essentially ceased. Also, the adoral sutures of the larger of the syntypes are very closely spaced and crowded, indicating that a late mature stage of growth had been reached. The whorls are helmet-shaped in cross section, as they are broadly rounded ventrally, only slightly flattened laterally, and impressed dorsally. They are slightly but distinctly broader than high. The phragmacone of one specimen (pl. 20, fig. 18) attains a maximum diameter of about 4 mm, and near its adoral end the height of the conch measures about 2.4 mm, the height above the venter of the preceding volution measures about 1.6 mm, and the width of the conch measures about 2.8 mm. The umbilicus is small and nearly closed. The umbilical shoulders are distinct and the umbilical walls are steep.

The test is thin and is marked by sinuous growth-lines. Each growth-line forms a shallow broadly rounded ventral sinus and on either side of it a small low rounded ventro-lateral salient, a similar lateral sinus, and a similar but small dorso-lateral salient. At late maturity the ventro-lateral salient becomes very prominent, and rounded ventro-lateral lappets are developed as projections on the apertural margins. Also, numerous

faint longitudinal ("spiral") lines can be discerned on some of the syntypes—these may be limited to an inner layer of the test.

The sutures are rather closely spaced during maturity, and the flanks of the ventral lobe of each are in contact with the preceding suture. The ventral lobe is deep, narrow, straight-sided, and blunt—during early maturity its adapical end is broadly rounded but eventually it becomes slightly concave, and the lobe is therefore incipiently bifid during late maturity. The first lateral saddle is rounded and U-shaped. The first lateral lobe is more or less V-shaped but is narrowly rounded. The second lateral saddle is asymmetrical and rounded. The lobe on the umbilical wall is broad and shallow, and it is somewhat flattened as the umbilical wall is slightly concave. The internal sutures consist of a deep narrow pointed tongue-shaped dorsal lobe and on either side of it a high narrow U-shaped saddle, a narrow tongue-shaped lobe, and a broad asymmetrical saddle which extends to the umbilical lobe. The siphuncle is located close to the ventral wall of the conch but not quite in contact with it, and therefore across the venter the sutures are continuous and are not reflected.

Remarks.—Recently Plummer and Scott have proposed the generic name *Neoaganides* for some small specimens from the Graham formation (Upper Pennsylvanian) of Texas that are similar to the above-described form. However, they did not point out any characters that would differentiate their specimens from *Imitoceras*, the genotype of which is *I. rotatorium* (De Koninck) of the Tournaisian of Belgium. The sutures of the genotypes of both *Neoaganides* and *Imitoceras* consist of the same number of elements in about the same general proportions and arrangement. Therefore, if both genera are to be recognized, they will probably have to be differentiated on the basis of ontogeny, the shape of the growth-lines, or the size of the conch. It seems very doubtful indeed that the ontogeny of the two forms is appreciably different, and the shape of the growth-lines is of uncertain value. In general, size is hardly a valid generic distinction. However, it is worthy of note that all of the Pennsylvanian and Permian forms known that have simple sutures like those

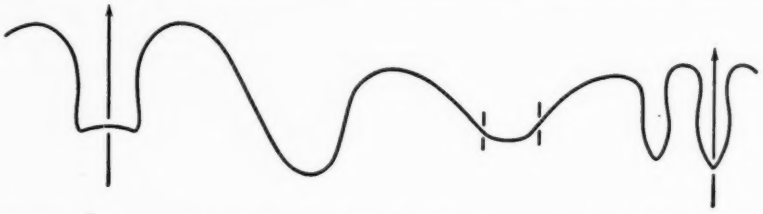


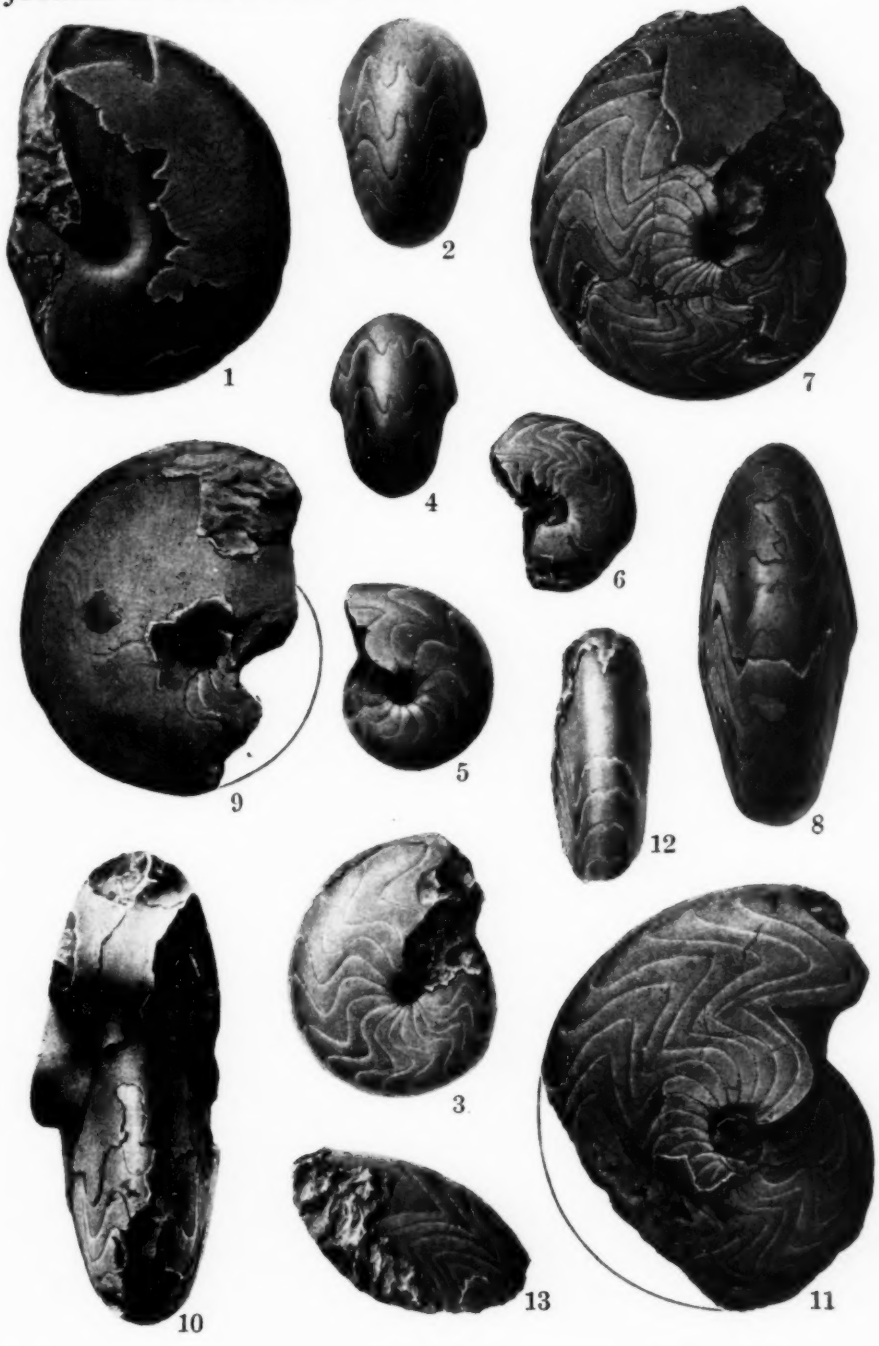
FIG. 2.—Diagrammatic representation of a late mature suture of *Imitoceras cherokeense* Miller and Owen, n. sp., ×17.5; based on the specimen represented on plate 20, figure 18.

EXPLANATION OF PLATE 17

FIGS. *1–3*—*Anthracoceras missouriense* Miller and Owen, n. sp. Lateral view, ×1½, of a rather large specimen and two views, ×2, of a well-preserved internal mold; from 10 to 15 feet below the Jordan coal member of the Cherokee formation in Henry County, Missouri. (p. 147)

4, 5—*Anthracoceras oklahomense* Miller and Owen, n. sp. Two views, ×2, of the holotype; from the middle part of the Boggy formation in Pontotoc County, Oklahoma. (p. 149)

6–13—*Goniolobocerας eliasi* Miller and Owen, n. sp. *6*, Lateral view, ×2, of a small specimen from just above the Tebo coal member of the Cherokee formation in Henry County, Missouri. *7, 8*, Two views, ×2, of an internal mold (the holotype) from just above the Mulky coal member of the Cherokee formation in Henry County, Missouri. *9–11*, Lateral view, ×1, and two views, ×2, of two specimens from just above the One-Foot coal member of the Cherokee formation in Vernon County, Missouri. *12, 13*, Two views, ×1, of a fragment of a rather large internal mold from just above the Tebo coal member of the Cherokee formation in Henry County, Missouri. (p. 156)



Miller and Owen, Upper Carboniferous Ammonoids

UNIV. OF MICH.

of the genotype of *Imitoceras* are less than 15 mm in diameter, whereas most of the Lower Mississippian and Upper Devonian forms attain a much larger size. It may possibly be, therefore, that the Pennsylvanian and Permian forms are degenerate representatives of an entirely different stock (or stocks) and therefore generically distinct from typical *Imitoceras*. Nevertheless, it seems to us that for the present at least, it will be best to refer all of the Late Paleozoic forms with similar sutures to *Imitoceras*.

The species under consideration can be readily differentiated from all previously described forms by the unique shape of the ventral lobe of its sutures.

Occurrence.—All of the known representatives of this species came from just above the Mulky coal member of the Cherokee formation in the Ewing strip pit, sec. 36, T. 43 N., R. 28 W., in Henry County, Missouri.

Syntypes.—Private collection of John Britts Owen, nos. 625 (figured specimens) and 626.

ANTHRACOCERAS MISSOURIENSE

Miller and Owen, n. sp.

Plate 17, figures 1–3

Description of this species is based on six specimens, all of which came from the same horizon and locality. Slight but distinct variations are recognizable amongst them, but all are probably conspecific.

The outer volution of the larger of the figured specimens is nonseptate throughout, and therefore presumably it represents the living chamber. The preserved portion of this specimen attains a maximum diameter (measured across the umbilicus) of about 35 mm and a maximum height and width of conch of about 19 mm and 16 mm, respectively. One of the six syntypes is a large fragmentary specimen representing part of the living chamber, and its conch appears to have been at least twice as high as that of the figured specimen just mentioned. The smaller syntypes are relatively wider, and the conch of the smaller of the figured specimens (which is septate throughout) is slightly wider than high.

The umbilicus is small but not entirely closed, and its diameter is equal to almost one-fifth that of the specimen. The umbilical shoulders are rounded and not very definite.

The test is thin and marked only by the strongly sinuous growth-lines. Each of these forms a deep rounded ventral sinus flanked on either side by a prominent high rounded ventro-lateral salient, a shallow broad rounded lateral sinus, and a very low broad rounded dorso-lateral salient. The internal mold bears traces of the growth-lines, obscure longitudinal striae, and rounded sinuous transverse constrictions—the constrictions, which are approximately parallel to the growth-lines and number three or four to the volution, become obsolete on the outer volutions of large mature specimens. Also, near the extreme adoral end of the larger of the figured specimens, on the internal mold, at least, there appears to be a shallow rounded adapertural constriction essentially parallel to the growth-lines. On one of the fragmentary syntypes, an internal mold of part of the phragmacone, there is a rather prominent longitudinal groove, which is located on the ventral side of the specimen somewhat to one side of the middle.

Each mature suture forms a low broad prominently subdivided ventral lobe and on either side of it a narrowly rounded more or less V-shaped first lateral saddle, an obtusely pointed V-shaped lateral lobe, a low broad rounded asymmetrical second lateral saddle, and a small pointed lobe just outside the umbilical seam (see text figure 3B). The sides of the ventral lobe converge apicad, and the prongs (major subdivisions) of that lobe are asymmetrically pointed and (at least in the smaller of the figured syntypes) are distinctly wider than the secondary saddle between them.

Remarks.—One of the six syntypes, which is only slightly smaller than the figured septate specimen, is somewhat more robust than that specimen and its sutures differ slightly in that the lateral and ventral lobes are relatively narrow and the prongs of the ventral lobe are not quite as wide as the secondary saddle between them. Otherwise these two specimens are very similar indeed, and in view of the proved sexual dimorphism in modern nautiloids and variations known to exist in fossil forms, we do not believe these two specimens should be re-

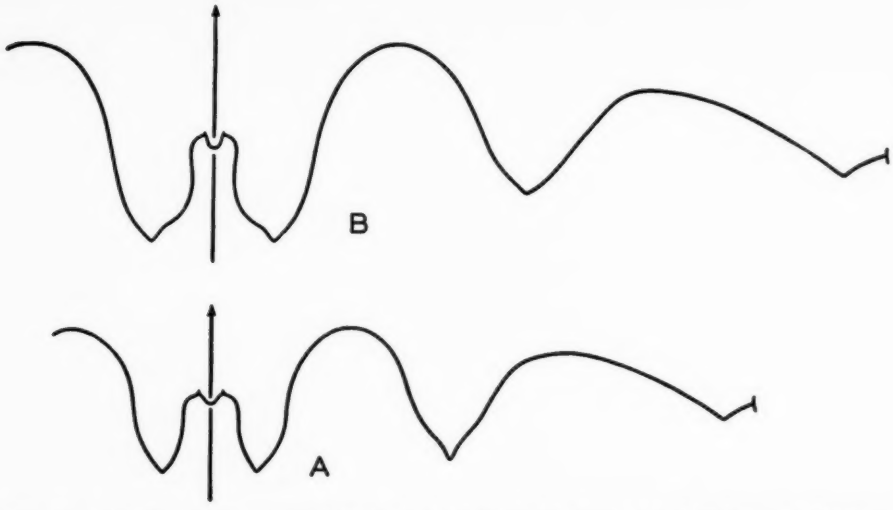


FIG. 3.—Diagrammatic representations of external sutures of (A) *Anthracoceras oklahomense* Miller and Owen, n. sp., and (B) *Anthracoceras missouriense* Miller and Owen, n. sp., both ×7.5. (Based on the specimens represented by figures 2–5, plate 17.)

garded as representing distinct species or varieties. On the smallest of the syntypes, which attains a maximum diameter (measured across the umbilicus) of only about 12 mm, the umbilical shoulders are slightly nodose, and the nodes seem to be formed by the growth-lines becoming fasciculate there. Unfortunately, sutures are not preserved on this small specimen. Its umbilicus is relatively larger than that of the late mature specimens. The growth-lines of this species are strikingly similar in configuration to those of the genotype of *Anthracoceras, A. discus* Frech of the basal Upper Carboniferous of Carolinengrube, Upper Silesia, Germany, and also the sutures of these two forms are in general similar. However, in the German species the median secondary saddle in the ventral lobe is relatively shallow and the major subdivisions of that lobe (as well as the lateral lobe) are narrowly rounded rather than pointed.

The specimens we are studying are also similar to *Anthracoceras wanlessi* Plummer and Scott, and they may prove to be referable to that species. The figured type specimens of *A. wanlessi* came from the limestone over Coal No. 2 in Fulton County, Illinois, but the species is stated by Plummer and Scott (1937, p. 323) to occur also "in the lower Strawn strata of Texas, and in the Cherokee formation of Missouri"—their Cherokee specimens probably represent *Bisatoceras greenei*. The sutures of the

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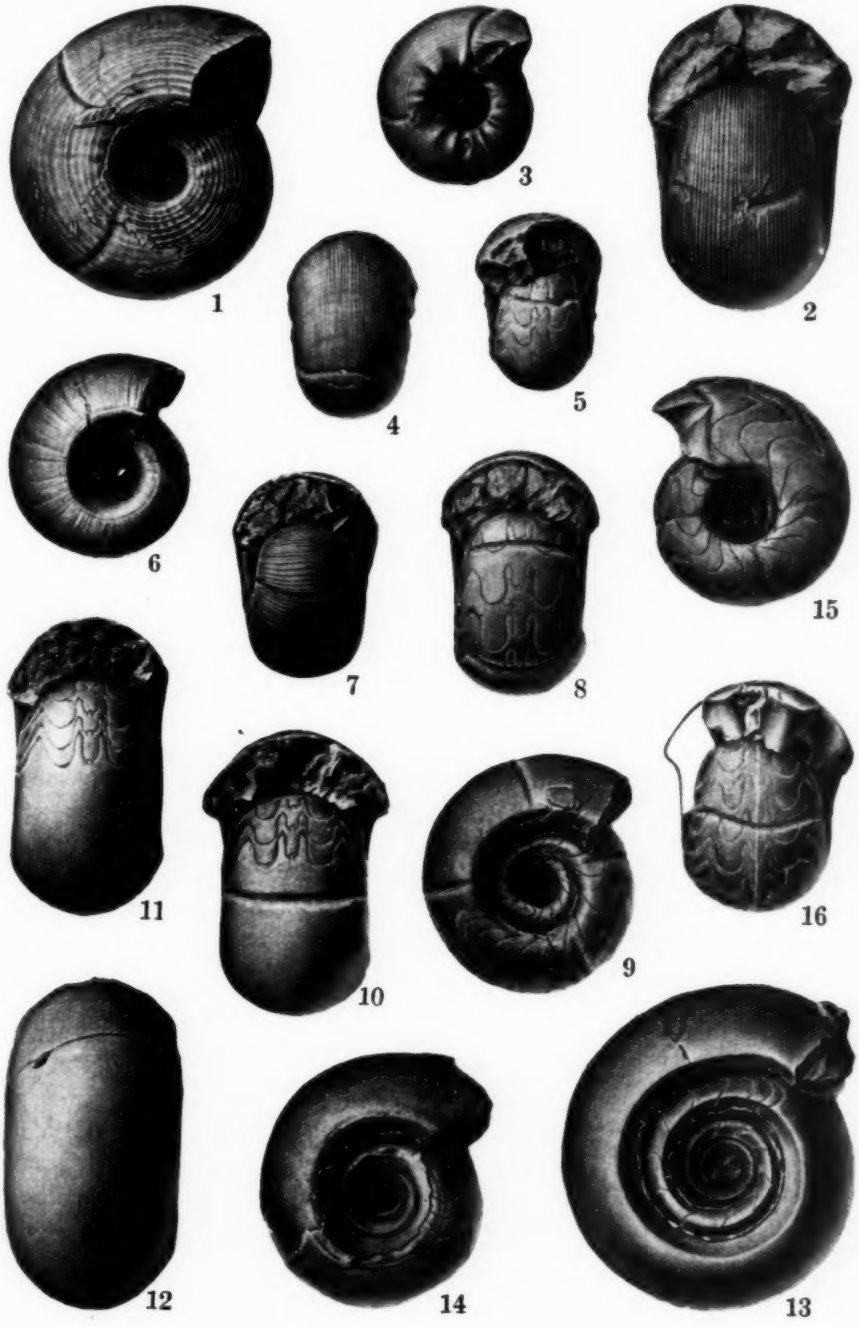
EXPLANATION OF PLATE 18

All specimens illustrated on this plate came from just above the Mulky coal member of the Cherokee formation in Henry (figs. *1–7, 10–16*) and Vernon (figs. *8, 9*) counties, Missouri.

FIGS. 1–5—*Neoglyphioceras bellilineatum* Miller and Owen, n. sp. *1, 2*, Lateral and ventral views of a moderately large specimen, a syntype. *3–5*, Three views of another syntype. All ×2. (p. 154)

6–16—Glaphyrites welleri (Smith). *6, 7*, A small well-preserved testiferous specimen. *8, 9*, An internal mold from Vernon County. *10*, A large internal mold showing a transverse constriction. *11*, All but the adoral portion of the specimen represented by figures *12* and *13*. *12, 13*, A large well-preserved internal mold showing a slight apertural constriction. *14*, A rather large specimen which retains a fragment of the test that shows a callosity in the form of a ridge on the umbilical shoulder. *15, 16*, And a moderately small specimen which shows the shape of the sutures. *6, 7, 15*, And *16* are ×2, whereas *8–14* are ×1. (p. 149)



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figured syntypes of *A. wanlessi* are more primitive than are those shown by our specimens at equal diameters.

Occurrence.—All six of the syntypes came from 10 to 15 feet below the Jordan coal member of the Cherokee formation in the England strip pit, sec. 17, T. 41 N., R. 25 W., Henry County, Missouri.

Syntypes.—Private collection of John Britts Owen, nos. 627 (figured specimens) and 628 (unfigured specimens).

ANTHRACOCERAS OKLAHOMENSE

Miller and Owen, n. sp.

Plate 17, figures 4, 5

Gastrioceras angulatum MORGAN [part], *1924*, [Oklahoma] Bureau of Geology, Bull. 2, p. 83, pl. 51, fig. 8 [not fig. 8a].

Holotype, only known representative of this species, is a well-preserved internal mold, which is septate throughout and is composed of limonite. Its maximum diameter (measured across the umbilicus) is about 14 mm. Near the adoral end of this specimen the conch is about 8.5 mm high and 9.5 mm wide, and corresponding measurements taken near the adapical end of the outer volution of the specimen are about 3.5 mm and 5 mm, respectively..

Umbilicus small but deep and rather prominent, its diameter equal to about one-fifth that of specimen. Umbilical shoulders abruptly rounded, fairly distinct, and, at least on the internal mold, slightly nodose. Umbilical walls steep and approximately perpendicular to lateral sides of conch.

Traces of growth-lines preserved on the holotype, an internal mold, show that each growth-line forms a deep rounded ventral sinus and on either side of it a prominent high rounded ventro-lateral salient, a shallow rounded lateral sinus, and a very low rounded dorso-lateral salient. The small nodes on the umbilical shoulders are probably formed by the growth-lines becoming fasciculate there. The adapical half of the outer volution of the holotype bears two shallow rounded transverse constrictions, which are approximately parallel to the growth-lines. The adoral constriction is distinctly less prominent than the adapical one, and apparently the constrictions become obsolete on the adoral portion of the specimen. Obscure traces of longitudinal striae are also visible on the internal mold.

On the outer volution of the holotype each suture forms a large broad prominently divided ventral lobe and on either side of it a rounded somewhat U-shaped first lateral saddle, an acuminate V-shaped lateral lobe, a low broad asymmetrical second lateral saddle, and a small pointed lobe just outside the umbilical seam (see text figure 3A). The sides of the ventral lobe converge apicad, and the prongs (major subdivisions) of the ventral lobe are asymmetrically pointed and are narrower than the secondary saddle between them.

Remarks.—This species is very closely similar to the form described above, *Anthracoceras missouriense*. However, it differs from that species in that its umbilical shoulders are more prominent, the nodes on its umbilical shoulders are retained during later growth-stages, and its sutures present certain obvious minor differences (compare text figures 3A and 3B). It differs from the genotype, *A. discus* Frech, and from *A. wanlessi* in that the median secondary saddle in the ventral lobe of its sutures is relatively high and the lobes of its external sutures are pointed rather than narrowly rounded.

Occurrence.—Middle part of Boggy shale, near the center of the NE¼ sec. 22, T. 3 N., R. 7 E., Pontotoc County, Oklahoma.

Holotype.—Columbia University, 18459.

GLAPHYRITES WELLERI (Smith)

Plate 18, figures 6–16

? Goniatites planorbiformis BROADHEAD, *1873*, Missouri Geol. Survey, Prelim. Rept. Iron Ores and Coal Fields, 1872, pt. 2, p. 61. [Not *G. planorbiformis* SHUMARD, *1855*.]

Gastrioceras welleri SMITH, *1903*, U. S. Geol. Survey, Mon. 42, p. 98, pl. 24, figs. 13–20.—GIRTY, *1915*, Missouri Bur. Geology and Mines, 2d ser., vol. 13, pp. 270, 364.—SMITH, *1927*, U. S. Geol. Survey, Prof. Paper 141, pl. 20, figs. 14–17.—BISAT, DUNCAN, and MOORE, *1931*, Yorkshire Geol. Soc., Proc., n. ser., vol. 22, pp. 6, 7, text figs. 3–5.—SMITH, *1932*, U. S. Geol. Survey, Prof. Paper 167, p. 24, pl. 43, figs. 14–17.

Glaphyrites welleri (Smith) PLUMMER and SCOTT, *1937*, Univ. Texas, Bull. 3701, pp. 267–268, pl. 15, figs. 13–21.

Conch subglobular to thickly subdiscoidal and moderately large. It appears, from a study of the numerous specimens in our collections, that the conch attains a maxi-

mum diameter of slightly less than 50 mm and a corresponding maximum height and width of conch of about 12.5 mm and 25 mm, respectively. We have perhaps a dozen specimens that seem to have attained approximately these dimensions. However, we have one specimen from the same general horizon and locality that attains a maximum diameter of about 56 mm.

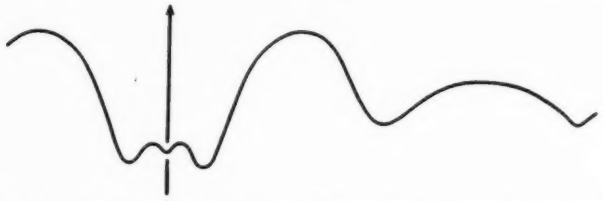

FIG. 4.—Diagrammatic representation of an external suture of *Anthracoceras discus* Frech, considerably enlarged; based on the holotype, which apparently attained a diameter of more than 50 mm. (Adapted from Frech.)

The whorls are low and broad, particularly at maturity, and are almost trapezoidal in cross section. They are very broadly rounded ventrally and only slightly impressed dorsally. The width of the umbilicus varies considerably in different specimens and in different parts of the same specimen. During adolescence the umbilicus is very broad, but during early maturity it becomes somewhat narrower. However, in general, its width seems to increase slightly during late maturity, for in moderate-sized specimens it typically varies between two-fifths and one-half the diameter of the conch, whereas in large specimens it typically varies between one-half and three-fifths that diameter. The living chamber is slightly more than one full volution in length. Near the adoral end of large specimens there is developed a broad shallow apertural constriction (see pl. 18, fig. 13).

The test is marked by fine growth-lines, which are slightly sinuous. Each forms a low broad somewhat flattened ventral salient, and on either side of it a small shallow rounded ventro-lateral sinus and a small low salient which centers on or near the umbilical shoulder. Also, with few exceptions, all of the testiferous specimens in our collections have some four or five longitudinal lirae on the umbilical shoulder (see pl. 18, fig. 6). In the large specimen represented on plate 18, figure 14, the test is thickened greatly on the umbilical shoulder. On the outside of the shoulder there is a rather prominent rounded raised line, which is represented also on the internal mold. The umbilical shoulders of some moderately large internal molds seem to be very slightly nodose, but in most of the specimens in our collections this is not the case. An inner layer of the test is marked by numerous fine discontinuous wavy transverse lines or pustules, similar to those that occur on the so-called "Runzelschicht" of other Paleozoic ammonoids.

With the exception of the outermost volution of large specimens, the internal mold (and in at least some cases the exterior of the test) is marked by a few rounded transverse constrictions, which are slightly sinuous and are essentially parallel to the growth-lines. The number and spacing of these constrictions varies considerably in different specimens and in different parts of the same specimen, but for the most part there are three to five (typically four) of them to the volution. However, we have a few specimens from just above the Tebo coal member of the Cherokee formation in which the constrictions are very closely spaced and number from five to ten to the volution. At first we were inclined to regard these specimens as representing a distinct species or variety, but aside from the constrictions they do not appear to differ essentially from typical forms. Furthermore, the number of constrictions in them is not constant, and on specimens from the same horizon (just above the Tebo coal) it varies from four to ten per volution.

The sutures of this species are of the typical gastrioceran type. At maturity each

of them forms a large bifid ventral lobe and on either side of it a slightly asymmetrical U-shaped first lateral saddle, a sharply pointed somewhat tongue-shaped first lateral lobe, a broad low rounded asymmetrical second lateral saddle, a low pointed lobe on the umbilical wall, a broad shallow rounded internal second lateral saddle, a rather deep pointed tongue-shaped internal first lateral lobe, and a high rounded internal first lateral saddle, which extends to the deep pointed spatulate dorsal lobe. During late maturity all of the lobes and saddles (and particularly the median saddle in the ventral lobe) become relatively longer and narrower, the flanks of the ventral lobe become essentially parallel, and the lobes become more sharply pointed.

Remarks.—This form is by far the most abundant ammonoid species in the Cherokee formation of Missouri, and the collections we are studying contain some 250 representatives of it. Most of these came from just above the Mulky coal member of the Cherokee formation at numerous localities in west-central Missouri, but a few of them came from just above the Tebo coal member of that formation in the same general locality. As might be expected, there is a great deal of variation within all of these specimens, but it seems to us that there is little to be gained by picking out the extreme variants and assigning them specific or varietal names. Therefore, we are referring all of them to Smith's species and allowing it considerable latitude. In almost every case when we have been able to study a large number of specimens from

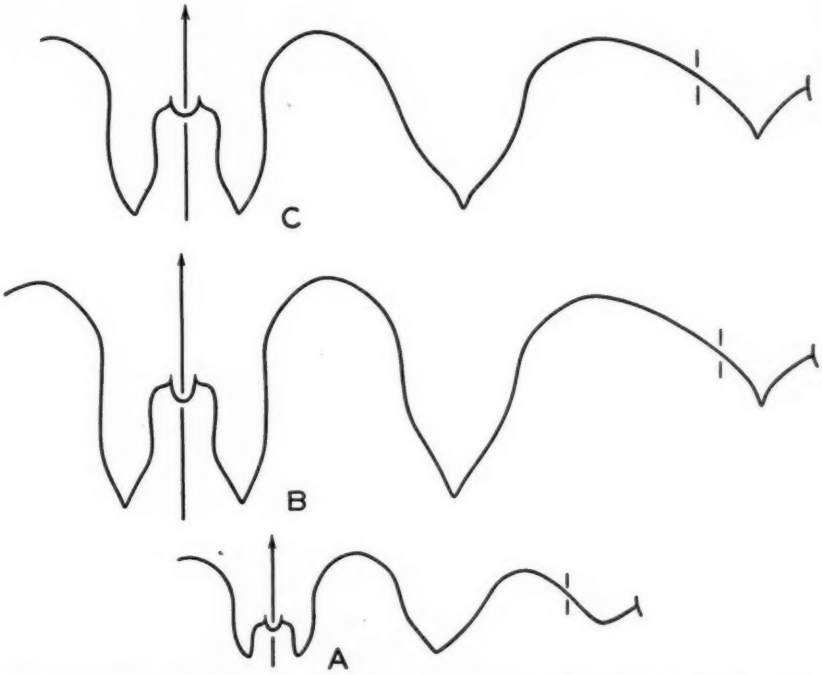

FIG. 5.—Diagrammatic representations of (A) an early mature and (B) a late mature suture of *Glaphyrites welleri* (Smith) and (C) a late mature suture of *Neoglyphioceras bellilineatum* Miller and Owen, n. sp. A is ×10, and it represents the sutures where the conch is about 8 mm in diameter, 6 mm wide, and 2.5 mm high. B, which is based on the same specimen as figure 10 on plate 18, is ×6, and it represents the sutures where the conch is about 33 mm in diameter, 18 mm wide, and 6 mm high. C is ×7.5, and it represents the sutures where the conch is about 17 mm in diameter, 12 mm wide, and 5 mm high.

one horizon and locality, a comparable amount of variation exists.

Smith compared this species with "*Gastrioceras*" *kingi* (Hall and Whitfield) and "*G.*" *globosum* (Meek and Worthen), but the relationship is not particularly close. *Glaphyrites clinei* (Miller and Owen) of the Coffeyville formation (lower Missouri series) of Oklahoma seems to us to be very similar to the form under consideration, but its conch is relatively broader and typically its sutures are farther advanced. The variety *G. clinei warei* (Miller and Owen), is however, almost identical with typical *G. welleri*.

Occurrence.—The syntypes of this species came from some unrecorded horizon and locality in the Cherokee formation of Carroll County, Missouri. The specimens which in 1915 Girty referred to it came from a yellow sandy shale member of the Cherokee formation "40 feet above top of Boone as seen in shaft" and "not far above base" of Cherokee, at "old Jordan coal bank, center sec. 25, T. 41, R. 26," Henry County, Missouri; and from 3 miles southeast of Higginsville, Lafayette County, Mo. (on road in SE¼NW¼ sec. 15, T. 49 N., R. 25 W.), almost certainly from just above the Mulky coal horizon in the Cherokee formation [and not from the "Fort Scott limestone member (?) of Henrietta formation," as stated by Girty]—in the collections we are studying there are four representatives of this species from Girty's Higginsville locality. The specimen figured by Smith in 1927 and again in 1932 came from the Upper Pennsylvanian at Howard, Kans.—it is very doubtful that this specimen belongs in the species under consideration. Bisat, Duncan, and Moore's specimens came from just above the Mulky coal member of the Cherokee formation in the Ewing strip pit, sec. 36, T. 43 N., R. 28 W., Henry County, Missouri. Plummer and Scott state that this species is known from the "Millsap Lake formation from a locality near the Palo Pinto-Erath county line in Erath County 6 miles west of Patillo [Texas]; . . . and perhaps from middle Pennsylvanian of Montgomery County, Illinois."

Most of the numerous specimens in the collections we are studying came from just above the Mulky coal member of the Cherokee formation in west-central Missouri and adjacent portions of Kansas, but a few of them came from just above the Tebo coal member of the Cherokee in the same general locality. The great majority of our specimens (and those represented by figures 10–13 on plate 18 and by text figures 5A and 5B) came from the Ewing strip pit, sec. 36, T. 43 N., R. 28 W., in Henry County, Missouri. Elsewhere in Henry County this species occurs abundantly just above the Mulky coal in the Lear strip pit, sec. 15, T. 43 N., R. 28 W. (pl. 18, figs. 6, 7), and rather sparsely at the same horizon in the Overby strip pit, sec. 21, T. 43 N., R. 28 W. (pl. 18, fig. 14); the Houston strip pit, sec. 19, T. 42 N., R. 25 W. (pl. 18, figs. 15, 16); the Shideler strip pit, sec. 22, T. 43 N., R. 28 W.; the Carroll strip pit, sec. 9, T. 42 N., R. 25 W.; the Gooch strip pit, sec. 15, T. 43 N., R. 28 W.; and the George Howell strip pit, sec. 19, T. 42 N., R. 25 W. In Vernon County, Missouri, this species occurs just above the Mulky coal in sec. 19, T. 35 N., R. 33 W. (pl. 18, figs. 8, 9); and in Bourbon County, Kansas, it occurs at the same horizon 3 miles south and 3 miles west of Eve, Mo. All of the few representatives of this species that we have from just above the Tebo coal member of the Cherokee formation came from near Highway 63, about 6½ miles north of Columbia, Boone County, Mo., and from the following localities in Henry County, Mo: the Coon Creek strip pit, sec. 22, T. 42 N., R. 26 W.; the Tillman strip pit, sec. 23, T. 42 N., R. 26 W.; the Vansant strip pit, sec. 22, T. 41 N., R. 27 W.; and the Carroll strip pit, sec. 9, T. 42 N., R. 25 W.—both the Mulky and the Tebo coals are exposed in the Carroll pits.

Types.—The syntypes of this species are in the Walker Museum of the University of Chicago, where they are numbered 1313.

EXPLANATION OF PLATE 19

FIGS. *1, 2*—*Glaphyrites moorei* Miller and Owen, n. sp. Lateral view and diagrammatic representation of a suture of the holotype, both ×1; from just above the Tebo coal member of the Cherokee formation in Henry County, Missouri. (p. 153)

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The specimen figured by Bisat, Duncan, and Moore is in the private collection of E. W. J. Moore of Rossendale, Lancashire, England; and the hypotypes figured by Plummer and Scott are at the Bureau of Economic Geology of the University of Texas. With the exception of one specimen (University of Missouri, no. 6267) from 6½ miles north of Columbia, Mo., all of the specimens studied by us are in the private collection of John Britts Owen, where they are numbered, 629 (pl. 18, figs. 6, 7), 630 (pl. 18, figs. 8, 9), 631, (pl. 18, fig. 10 and text figure 5B), 632 (pl. 18, figs. 11–13), 633 (pl. 18, fig. 14), 634 (pl. 18, figs. 15, 16), 635 (text figure 5A), and 636–651.

GLAPHYRITES MOOREI

Miller and Owen, n. sp.

Plate 19, figures 1, 2

Conch large, and phragmacone attains a maximum diameter (measured across the umbilicus) of at least 135 mm. Whorls rounded laterally and ventrally and impressed dorsally. Holotype, only known representative of species, was somewhat crushed laterally and distorted during fossilization, and only one side of it is preserved. Near adoral end of this specimen, conch (in its present somewhat crushed state) is about 60 mm high, and it appears to have been considerably wider than high. Umbilicus moderately large, and its diameter is equal to about one-third that of specimen. Umbilical shoulders rounded and not very well defined. Umbilical walls steep and approximately perpendicular to lateral sides of conch.

Surface of internal mold, at least, smooth. Faint traces of growth-lines are preserved on the holotype, an internal mold. These are nearly straight on the lateral zones of the conch, but each forms a shallow ventral sinus.

Each mature suture forms a broad prominently bifid ventral lobe and on either side of it a large narrowly rounded club-shaped first lateral saddle, a narrow pointed tongue-shaped first lateral lobe, a broader asymmetrical rounded second lateral saddle, a short acuminate lobe on the umbilical wall, a broad rounded internal second lateral saddle, a narrower internal lateral lobe, and a narrow internal first lateral saddle, which extends to the dorsal lobe. The precise shape of the internal lobes and saddles can not be ascertained from the holotype, but presumably they do not differ greatly from those of other congeneric forms. The median secondary saddle in the ventral lobe is about two-thirds as high as the lobe is deep, and it is considerably wider than the prongs (secondary lobes) of the ventral lobe.

Remarks.—The holotype of this species is vastly larger than any of the forms with which it was found in association. In size and general physiognomy it resembles the specimens that are commonly referred to *Glaphyrites* ["*Gastrioceras*"] *excelsus* (Meek). The holotype of that species came from the Pennsylvanian of eastern Kansas at Osage; N. D. Newell has told us that stratigraphically it probably came from between the Topeka and the Howard formations of the Shawnee group. It has never been figured, but photographs of it kindly made for us by Dr. G. A. Cooper of the U. S. National Museum (where the type specimen is deposited) show that it is very incomplete and distorted. However, in 1903 J. P. Smith (pp. 88–89, pls. 28, 29) figured and described a large well-preserved congeneric specimen from the same locality and probably from the same horizon. Presumably this specimen is conspecific with the holotype, as Smith thought, and if that is the case, *G. moorei* can be differentiated from *G. excelsus* by means of its smaller umbilicus and the details of its sutures.

The form from the Coffeyville formation (basal Missouri series) of Oklahoma that we recently described as *Gastrioceras clinei* is also similar to the species under consideration. However, all of the known representatives of the Coffeyville form are much smaller than the holotype of *Glaphyrites moorei*, and the first lateral lobes of their sutures are relatively broad.

This species is named for Prof. R. C. Moore, in recognition of his studies of the Carboniferous.

Occurrence.—Holotype, only known representative of this species, came from just above the Tebo coal member of the Cherokee formation in the J. G. Turk strip pit on Crow Branch, sec. 10, T. 41 N., R. 27 W., Henry County, Missouri.

Holotype.—Private collection of John Britts Owen, no. 652.

NEOGLYPHIOCERAS BELLILINEATUM
Miller and Owen, n. sp.
Plate 18, figures 1–5

Conch subglobular and attains a maximum diameter of at least 26 mm and a maximum height and width of at least 9 mm and 17 mm, respectively. Whorls are low and broad throughout ontogenetic development. They are helmet-shaped in cross section as they are broadly rounded ventrally and ventro-laterally and rather deeply impressed dorsally. The living chamber is at least one full volution in length. The umbilicus is moderately large but is somewhat variable in size. Its width varies from slightly more than one-third the diameter of the specimen to one-half that diameter. The umbilical shoulders are abruptly rounded and are slightly nodose. In some specimens the nodes on the umbilical shoulders are much larger and more prominent than on others (compare, for example, the two figured specimens). However, this difference, like the variation in the width of the umbilicus, seems to be entirely gradational and therefore of no taxonomic significance. The umbilical walls are steep and are almost perpendicular to the adjacent portion of the lateral sides of the conch.

The surface of the test is marked by numerous closely spaced very fine growth-lines and by longitudinal ("spiral") lirae. The longitudinal lirae are larger and are considerably more prominent than the growth-lines. On the ventral and ventro-lateral zones of the conch these lirae are of about the same size as the spaces between them, but on the lateral zones they are somewhat less closely spaced. They are well developed on the umbilical shoulders but are not present on the umbilical walls. Each growth-line forms a broad rounded ventral salient and on either side of it a similar but somewhat narrower ventro-lateral sinus and a smaller salient, which centers on or near the umbilical shoulder. Traces of both the growth-lines and the longitudinal lirae are generally preserved on the internal mold. Also, at least the internal mold is marked by rounded sinuous transverse constrictions. There are about four of these to the volution and they are essentially parallel to the growth-lines but do not continue across the umbilical walls. In some specimens these constrictions seem to be confined to the internal mold, but in others they are clearly reflected in the test.

At maturity each external suture consists of an almost straight-sided bifid ventral lobe and on either side of it a rounded U-shaped asymmetrical first lateral saddle, a sharply pointed somewhat tongue-shaped first lateral lobe, a rather low broad asymmetrical rounded second lateral saddle, and a shallow broad pointed lobe on the umbilical wall. The median saddle in the ventral lobe becomes more than half as high as the lobe is deep, and it is distinctly wider than the prongs of that lobe (see text figure 5C). The internal sutures are of the typical gastrioceran type and consist of a dorsal lobe and on both sides of it one lobe and two saddles.

Remarks.—With the exception of certain rather minor differences in the ventral lobe of its sutures and the small nodes on its umbilical shoulders, this species resembles rather closely the genotype of *Neoglyphioceras*, *N. spirale* (Phillips) of the Viséan of England. Although we are inclined to doubt that the relationship between these two species is particularly close, the only differences we can point out are hardly sufficient to be regarded as of generic significance. "*Gastrioceras*" *retiferum* Miller and Owen of the Coffeyville formation (lower Missouri series) of Oklahoma is much closer to our form than any other species with which we are familiar, and the two are clearly congeneric. However, in the Oklahoma form the conch is relatively broad, the longitudinal lirae are relatively coarse, and there are no nodes on the umbilical shoulders.

Occurrence.—All of the known representatives of this species came from just above the Mulky coal member of the Cherokee formation in Henry and Lafayette counties, Missouri. The larger of the figured specimens and 18 unfigured ones came from the Ewing strip pit, sec. 36, T. 43 N., R. 28 W., in Henry County; the smaller of the figured specimens and 4 unfigured ones came from the Shideler strip pit, sec. 22, T. 43 N., R. 28 W., in Henry County; and of the remainder of the syntypes, 8 specimens

came from the Lear strip pit, sec. 15, T. 43 N., R. 28 W., in Henry County, and one came from near a road in the SE ¼ NW ¼ sec. 15, T. 49 N., R. 25 W., 3 miles southeast of Higginsville in Lafayette County.

Syntypes.—Private collection of John Britts Owen, nos. 653 (pl. 18, figs. 1, 2), 654 (pl. 18, figs. 3–5), 655 (text fig. 5C), and 656–659.

BISATOCERAS GREENEI Miller and Owen, n. sp.

Plate 20, figures 1–7

?Goniatite [of uncertain affinities] BISAT, DUNCAN, and MOORE, *1931*, Yorkshire Geol. Soc., Proc., n. ser., vol. 22, p. 6.

?Anthracoceras wanlessi [part] PLUMMER and SCOTT, *1937*, Univ. Texas, Bull. 3701, pp. 322–323 [not pl. 8, figs. 21–24].

Conch subdiscoidal throughout ontogenetic development. At maturity it attains a maximum diameter of at least 26 mm, and the living chamber is at least one full volution in length. Near adoral end of holotype (pl. 20, figs. 1, 2) conch is about 18 mm in diameter, and its height and width measure about 10.5 and 8 mm, respectively. Even early volutions of conch are similarly compressed and are slightly higher than wide. Umbilicus small and closed during adolescence as well as at maturity. Umbilical shoulders low, rounded, and inconspicuous.

Test thin and marked only by growth-lines, which, however, are rather prominent, particularly during adolescence. All of the type specimens that retain portions of the test have the delicate growth-lines exceptionally well preserved, and in some cases traces of them are present on the internal mold. Each growth-line forms a moderately deep ventral sinus and on either side of it a prominent ventro-lateral salient, a shallower and broader lateral sinus, and a low dorso-lateral salient. All of the sinuses and salients formed by the growth-lines are rounded, and the ventro-lateral salients are much more prominent than the dorso-lateral ones. Internal mold (but not exterior of test) of early volutions of conch is marked by rounded transverse constrictions, which are more or less parallel to the growth-lines but are less strongly sinuous. Both the number and prominence of these constrictions seems to vary in different specimens, but invariably the constrictions are confined to portions of the conch less than 8 mm in diameter.

The ventral lobe of the sutures becomes bifid during early adolescence, and then the prongs of that lobe become progressively deeper and broader. Eventually the median saddle in the ventral lobe is much narrower than the prongs of that lobe and is about two-thirds as high as the prongs are deep.

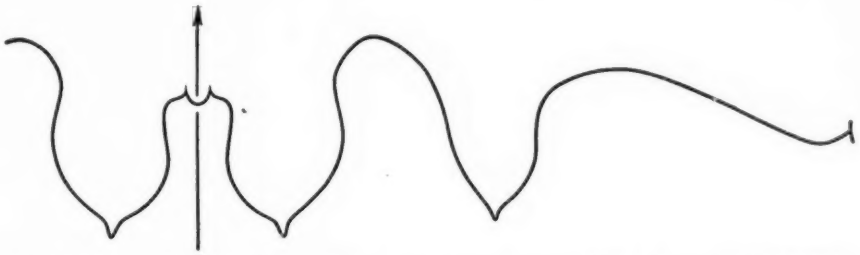


FIG. 6.—Diagrammatic representation of a mature suture of *Bisatoceras greenei* Miller and Owen, n. sp., ×7.5; based on the holotype, where the conch is about 8.5 mm high and the specimen is about 14 mm in diameter.

At full maturity the prongs of the ventral lobe are acuminate, and on the extreme adoral end of the holotype their tips are curved toward the venter. The first lateral saddle, which is rounded, becomes relatively narrower throughout ontogenetic development as the prongs of the ventral lobe become broader. The first lateral lobe is asymmetrical and at full maturity is acuminate. The second lateral saddle is broad, asymmetrical, and broadly rounded. The lobe on the umbilical shoulder is shallow and is rounded. The internal sutures and the adolescent and early mature stages of the complete sutures do not appear to differ

materially from those of *Bisatoceras primum* which we recently illustrated and described in detail.

Remarks.—Mature stages of this species are quite similar to those of the genotype, *B. primum* Miller and Owen, and differ essentially from them only in that their conch is somewhat narrower. However, adolescent representatives of the two species (with diameters of some 5 mm) are strikingly different in shape, for those of the genotype are subglobular rather than subdiscoidal. None of the type specimens of this species shows a trace of longitudinal ("spiral") lines, which are present on the figured syntype of *B. secundum* Miller and Moore, the only other representative of the genus known.

The specific name of the above-described form is in honor of Frank C. Greene, who has added greatly to our knowledge of the Pennsylvanian rocks of Missouri.

Occurrence.—All of the known representatives of this species came from the Cherokee formation of Henry County, Missouri. The holotype was found just above the Tebo coal member of that formation, whereas all of the paratypes were collected from the beds immediately above the Mulky coal member. The holotype came from the West Missouri Power Company strip pit, sec. 23, T. 42 N., R. 26 W. Both of the figured paratypes and 33 unfigured specimens were collected in the Ewing strip pit, sec. 36, T. 43 N., R. 28 W., and the few remaining paratypes were found in the Shideler strip pit, sec. 22, T. 43 N., R. 28 W. and the George Howell strip pit, sec. 19, T. 42 N., R. 25 W.

Types.—Private collection of John Britts Owen, nos. 660 (holotype), 661 (figured paratypes), and 662–664.

GONIOLOBOCERAS ELIASI Miller and Owen, n. sp.

Plate 17, figures 6–13

?Goniatites Hathawayensis? BROADHEAD, *1873*, Missouri Geol. Survey, Prelim. Rept. Iron Ores and Coal Fields, 1872, pt. 2, p. 61. [Not *G. hathawayanus* MCCHESNEY, *1860*.]

We have seven specimens from the Cherokee of Henry, Vernon, and Johnson counties, Missouri, that are referable to *Goniloboceras*. They represent different portions of the conch and hence exhibit considerable variation. Nevertheless, it seems probable that all are conspecific, and we propose for the present, at least, to regard them as representing only one species.

The conch attains a maximum diameter of more than 50 mm. It is subdiscoidal or sublenticular in shape, and the whorls are compressed, flattened laterally, rather narrowly rounded ventrally, and deeply impressed dorsally. During late maturity a narrow indistinct flattened zone is developed along the venter (see pl. 17, fig. 12). Near the adoral end of the holotype (pl. 17, figs 7, 8) the conch is about five-sevenths as wide as high. The living chamber is at least three-fifths of a volution in length.

The umbilicus is small but not closed. The umbilical shoulders are rather abruptly rounded, and the umbilical walls are steep.

The test is thin. It is smooth and is marked by only the growth-lines, each of which forms ventral and lateral sinuses and ventro-lateral and dorso-lateral salients, all of which are rounded. The ventro-lateral salients are much more prominent and more narrowly rounded than are the dorso-lateral ones, and the latter are located outside the umbilical shoulders.

Each suture forms a total of eight lobes,

EXPLANATION OF PLATE 20

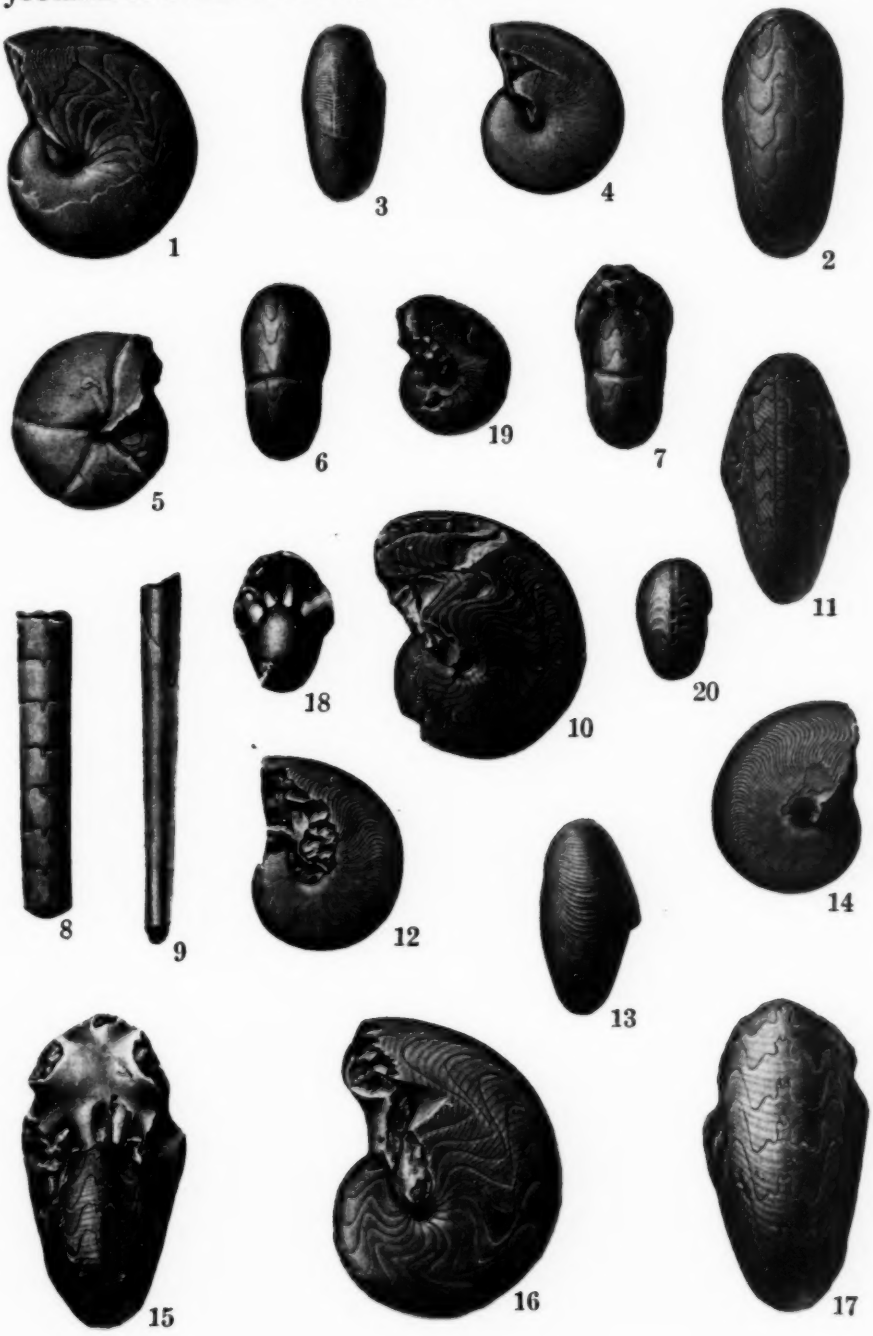
All specimens illustrated on this plate came from the Cherokee formation of Henry County, Missouri. The specimen represented by figures *1* and *2* came from just above the Tebo coal, whereas those represented by figures *3–20* came from just above the Mulky coal.

FIGS. *1–7—Bisatoceras greenei* Miller and Owen, n. sp. *1, 2*, Two views, ×2, of the holotype, a moderately large specimen. *3, 4*, Ventral and lateral views, ×2, of a smaller specimen, a paratype *5–7*, Three views, ×4, of an immature specimen, another paratype. (p. 155)

8, 9—Bactrites sp. Figure *8* is ×2; figure *9*, which represents another specimen, is ×1. (p. 144)

10–17—Dimorphoceras politum (Shumard). Lateral and ventral views, ×2, of the neoholotype; three views, ×2, of a small testiferous specimen; and three views, ×5, of an immature specimen. (p. 158)

18–20—Imitoceras cherokeense Miller and Owen, n. sp. Two of the syntypes, ×5. *19* And *20* represent the same specimen. (p. 145)



Miller and Owen, Upper Carboniferous Ammonoids

UNIV. OF MICH.

the ventral one of which is prominently divided. During adolescence the lobes and saddles are rounded, but when maturity is reached all of the lobes but the umbilical lobe gradually become pointed and the external first lateral saddles become very narrowly rounded and eventually pointed.

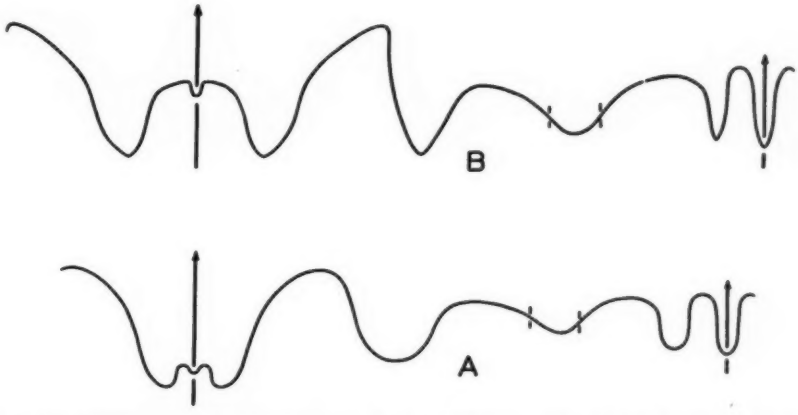


FIG. 7.—Diagrammatic representations of an adolescent and an early mature suture of *Goniloboceras eliasi* Miller and Owen, n. sp. A is ×10 and represents the sutures where the conch is about 3.7 mm high and about 2.3 mm wide; it is based on an unfigured specimen (John Britts Owen coll. no. 670) from just above the One-Foot coal member of the Cherokee formation, about 1 mile east of Eve, Vernon County, Mo. B is × 2.5 and represents the sutures where the conch is about 18 mm high and about 29 mm in diameter; it is based on the specimen represented by pl. 17, figs. 10, 11, which came from the same horizon and locality as the last.

The ventral flank of the external first lateral saddles is sigmoidal, but during late maturity, when the prongs (secondary lobes) of the ventral lobe become long and acuminate, this sigmoidal shape is lost (see pl. 17, fig. 13).

Remarks.—The above-described form is a rather primitive representative of *Goniloboceras*. Its sutures resemble rather closely those of *Goniatites parrishi* Miller and Gurley, the genotype of *Milleroceras*. However, evidence seems to be accumulating to indicate that the holotype of that species is an immature representative of *Goniloboceras*, rather than a mature representative of a distinct genus.

All of the known representatives of *Goniloboceras* are rather similar. Elias (1938, pp. 93–99) has recently concluded that we should refer all of them to two species, *G. goniolobum* (Meek) and *G. welleri* Smith, and that the latter "may be the female of *G. goniolobum*." Though this view may be correct, it is rather extreme, and for the present, at least, it will perhaps be best to retain most of the subdivisions that have been named, though possibly we should regard them as varieties rather than species. The type specimen of the genotype of *Goniloboceras*, *G. goniolobum* (Meek), came from some unknown horizon and locality in New Mexico. According to Elias, the type has been lost. If Meek's illustrations (drawings) of it are accurate, we have never seen a specimen that has sutures precisely like it, for the secondary ventral saddle is shown as being V-shaped rather than U-shaped. *G. eliasi* seems to be much closer to *G. welleri* Smith, in which the components of the sutures are less nearly angular. However, a direct comparison of the sutures of our specimens with equal-sized representatives of this species shows that the Cherokee form is distinctly more primitive in that the lobes and saddles of its sutures are narrowly rounded or only bluntly pointed, at least until late maturity. These differences, though easily recognized, are differences in degree, and doubtless

intermediate forms exist. It may be, therefore, that *G. eliasi* should be regarded as a variety of *G. welleri*, rather than a distinct species, but for the present, at least, we prefer to give it specific rank. Adequate comparisons with *G. parrishi* are not possible for the holotype of that species is small and probably immature, and mature representatives have not been recognized with certainty.

Occurrence.—All seven of the type specimens of this species came from the Cherokee formation of west-central Missouri. The holotype came from just above the Mulky coal in the George Howell strip pit, sec. 19, T. 42 N., R. 25 W., in Henry County. The paratypes came from just above the Tebo coal in the Carroll strip pit, sec. 9, T. 42 N., R. 25 W., in Henry County (pl. 17, fig. 6); just above the One-Foot coal, about 1 mile due east of Eve, Vernon County (text fig. 7 and pl. 17, figs. 9–11) [collected by J. P. Harner]; just above the Tebo coal in the Vansant strip pit, sec. 22, T. 41 N., R. 27 W. in Henry County (pl. 17, figs. 12, 13); and just above the Mulky coal, about 1¾ miles southeast of Leeton, Johnson County.

Types.—Private collection of John Britts Owen, nos. 665 (holotype, pl. 17, figs. 7, 8), 666 (pl. 17, fig. 6), 667 (pl. 17, fig. 9), 668 (pl. 17, figs. 10, 11), 669 (pl. 17, figs. 12, 13) 670 (text fig. 5A), and 671 (unfigured specimen).

DIMORPHOCERAS POLITUM (Shumard)

Plate 20, figures 10–17

Goniatites politus SHUMARD, *1858*, St. Louis Acad. Sci., Trans., vol. 1, p. 199.—BROADHEAD, *1873*, Missouri Geol. Survey, Prelim. Rept. Iron Ores and Coal Fields, 1872, pt. 2, p. 61.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 221.—WELLER, *1898*, U. S. Geol. Survey, Bull. 153, p. 295.—SMITH, *1903*, U. S. Geol. Survey, Mon. 42, p. 142.

Goniloboceras parrishi? GIRTY, *1915*, Missouri Bur. Geology and Mines, 2d ser., vol. 13, pp. 270, 364.

Homoceratoides jacksoni [part] BISAT, DUNCAN, and MOORE, *1931*, Yorkshire Geol. Soc., Proc., n. ser., vol. 22, pp. 1–8, [probably not text figs. 1, 2], pl. 1, figs. 1a–1c [probably not 2a–3].—MOORE, *1937*, Comptes rendus Deuxième Congrès pour l'avancement des études de stratigraphie carbonifère—Heerlen 1935, p. 666.—MOORE and ELIAS, *1937*, Comptes rendus Deuxième Congrès pour l'avancement des études de stratigraphie carbonifère—Heerlen 1935, p. 679.

Dimorphoceras politum PLUMMER and SCOTT, *1937*, Texas Univ., Bull. 3701, pp. 339–340, pl. 40, figs. 10–14.

Conch is moderate in size and attains a diameter (measured across the umbilicus) of at least 45 mm. During early adolescence conch is subglobular in shape. However, as ontogenetic development proceeds, conch expands much more rapidly in a dorsoventral than in a lateral direction, and it soon becomes higher than wide and at maturity is sublenticular in shape. The phragmacone of a large septate specimen attains a diameter of about 22 mm and a maximum height and width of conch of about 14 mm and 11 mm, respectively. The maximum width of the conch is attained just outside (ventrad of) the umbilical shoulders. The lateral zones of the mature portion of the conch, which converge ventrad rather strongly, are flattened but are slightly convex. The ventral side of the conch is rather narrowly rounded, and the dorsal side is deeply impressed. The impressed zone at maturity is equal to about two-fifths the height of the conch. The living chamber appears to be about one volution in length, but this determination needs verification. Unfortunately, the living chamber is crushed or very incomplete in all of the numerous specimens in our collection.

The umbilicus is small and appears to be closed throughout essentially all of ontogenetic development. The umbilical shoulders are rounded, but they are fairly abrupt and are rather prominent. The umbilical walls are moderately steep.

Surface of test is marked by sinuous growth-lines and by faint longitudinal ("spiral") lirae. The delicate surface ornamentation is well preserved on all of the testiferous specimens in our collection, and in at least some specimens traces of it can be clearly discerned on the internal mold. During early adolescence the growth-lines are fine and not very prominent, and longitudinal lirae are either absent or very faint. However, as maturity is approached longitudinal lirae are gradually developed, and the growth-lines become very prominent. Peculiarly enough, the growth-lines are again reduced in size and prominence during late maturity, but they are always more

conspicuous than the fine longitudinal lirae. Even during adolescence the growth-lines are sinuous, and they become more strongly sinuous throughout ontogenetic development. Each forms a rather deep ventral sinus and on either side of it a fairly prominent ventro-lateral salient, a shallow lateral sinus, and a low dorso-lateral salient. All of the sinuses and salients formed by the growth-lines are rounded. During adolescence and early maturity the dorso-lateral salients, which are less prominent than the ventro-lateral ones, center on or very near the umbilical shoulders. However, they gradually migrate ventrad, and on the adoral portion of late mature specimens, they are located distinctly outside (ventrad of) the umbilical shoulders.

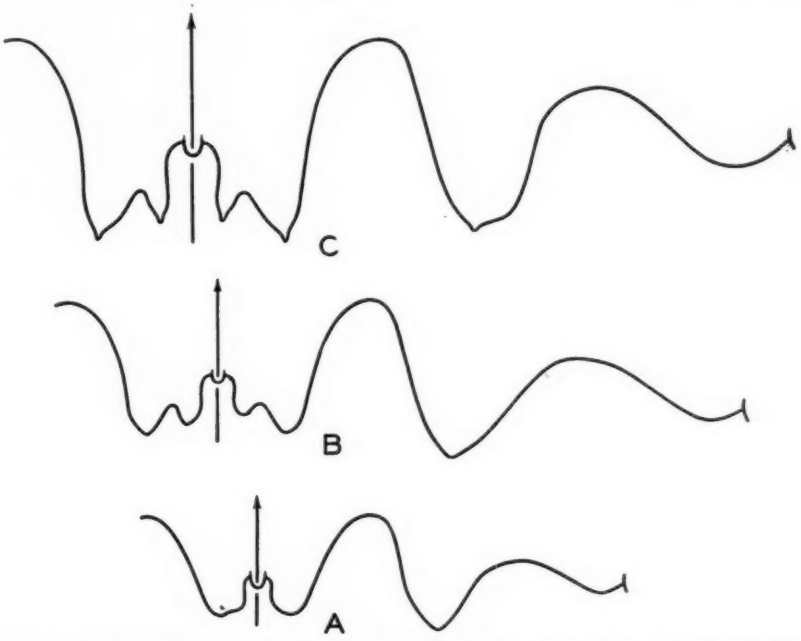


FIG. 8.—Diagrammatic representations of adolescent, and early and late mature sutures of *Dimorphoceras politum* (Shumard). A is ×15, and it represents the suture where the conch is about 4.5 mm in diameter, 2.8 mm wide, and 2.6 mm high. B is ×12.5, and it represents the sutures where the conch is about 7.2 mm in diameter, 4.4 mm wide, and 4.6 mm high. C is ×6, and it represents the sutures where the conch is about 16.5 mm in diameter, 8.5 mm wide, and 10.5 mm high. A and B are based on the specimen represented by figures 15–17 on plate 20, and C is based on a specimen (John Britts Owen coll. no. 675) from the Lear strip pit in Henry County, Missouri.

As shown by text figure 8 and figures 15–17 on plate 20, during early adolescence each suture forms a more or less V-shaped but bifid ventral lobe, and on either side of it a rounded somewhat U-shaped first lateral saddle, a V-shaped first lateral lobe, a low rounded second lateral saddle, and a small shallow lobe (an umbilical lobe), which centers on the umbilical wall. Then, as ontogenetic development proceeds, the median saddle in the ventral lobe becomes higher and U-shaped, and the rounded prongs of the ventral lobe gradually become bifid. In at least some cases, the rate of development of bifidity is unequal on the two sides of the same specimen (see text figure 8A). Figure 15 on plate 20 shows the change from undivided to bifid prongs of the ventral lobe. The small saddles that are developed in these prongs do not divide them symmetrically, and the ventral subdivision of each is smaller and shallower than the dorsal one.

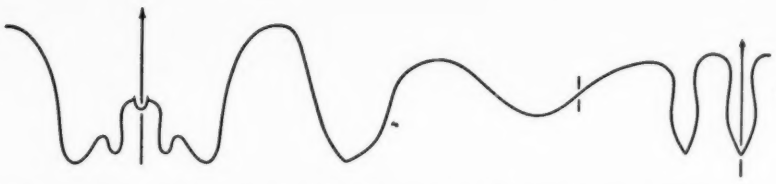


FIG. 9.—Diagrammatic representation of a mature suture of *Dimorphoceras politum* (Shumard), ×4; based on the neoholotype, where the conch is about 18 mm in diameter. The internal sutures are partially reconstructed.

The internal sutures at maturity consist of a deep narrow pointed tongue-shaped dorsal lobe and on either side of it a high narrow rounded more or less U-shaped internal first lateral saddle, a deep narrow pointed tongue-shaped internal first lateral lobe, and a low broad asymmetrical internal second lateral saddle which extends to the umbilical lobe (see text figure 9).

Remarks.—Shumard's original description of this species is brief, generalized, and quite inadequate, and it is not accompanied by an illustration. Furthermore, it was based on specimens which did not reveal the nature of the sutures and which appear to have been lost. However, the paleontological collections of the Walker Museum at the University of Chicago contain a topotype that was received in exchange from Shumard. Also, the Mulky coal horizon (which yielded our specimens) is represented near Lexington, Mo., whence came Shumard's type specimens. These considerations, together with the fact that Shumard's description, insofar as it goes, fits our specimens precisely, make it almost certain that we are dealing with Shumard's species, and we propose to regard the best of our specimens (pl. 20, figs. 10, 11) as a neoholotype. Also, the specimens from 3 miles southeast of Higginsville, Lafayette County, Mo., which in 1915 Girty tentatively placed with question in *Goniloboceras parrishi* "on the strength of a certain external resemblance" for he could not ascertain the nature of their sutures, almost certainly represent the species under consideration, for specimens in our collection from this locality are clearly conspecific with the above-described Henry County forms, and at the same time they coincide precisely with Girty's description.

Dimorphoceras politum resembles rather closely the genotype, *D. gilbertsoni* (Phillips) from the Viséan of England, but the external lateral lobes of its sutures are pointed rather than rounded, even during late adolescence. Bisat, Duncan, and Moore have stated that the above-described form is conspecific with specimens from the Upper Carboniferous of Scotland (and England), which they designate *Homoceratoides jacksoni* Bisat. However, insofar as we have been able to ascertain, only a very few representatives of this British species are known, and all of them are crushed and are rather fragmentary. It appears that the Scottish and American specimens are closely similar and are congeneric, but until better representatives of the British form have been found so that detailed comparisons can be made, it will perhaps be best to regard the two as specifically distinct. In any case, the American name has priority. The nature of the sutures of the genotype of *Homoceratoides* Bisat is not known, and therefore it is not possible to refer species (other than the genotype) to that genus with certainty. Anyhow, the form under consideration seems to us to be referable to *Dimorphoceras*, which again has priority.

It should perhaps be pointed out in this connection that the type species of *Shuichengoceras* Yin, *S. yohi* of the Lower Permian? of China, is related to the genotype of *Dimorphoceras* and may be congeneric with it. However, its sutures are slightly more advanced than are those of typical *Dimorphoceras* for almost all of the external lobes and saddles are angular. Therefore, it may be that we should regard this species as representing a distinct genus or subgenus, more or less intermediate between typical *Dimorphoceras* and typical *Neodimorphoceras*—in *Neodimorphoceras* the ventral lobe of the sutures is more strongly subdivided.

Occurrence.—The type specimens of this

species came from Lexington, Lafayette County, Mo.—presumably they came from the Cherokee formation. The numerous specimens in our collections that we are referring to this species came from just above the Mulky coal member of the Cherokee formation in Henry County, Missouri, at the George Howell strip pit, sec. 19, T. 42 N., R. 25 W. (text fig. 9; pl. 20, figs. 10, 11; and two unfigured specimens); the Ewing strip pit, sec. 36, T. 43 N., R. 28 W. (text figs. 8A, 8B; pl. 20, figs. 12–17; and 68 unfigured specimens); the Lear strip pit, sec. 15, T. 43 N., R. 28 W. (text fig. 8C and 13 unfigured specimens); the Houston strip pit, sec. 19, T. 42 N., R. 25 W. (1 specimen); and the Shideler strip pit, sec. 22, T. 43 N., R. 28 W. (2 specimens). Also, we have six conspecific specimens from 3 miles southeast of Higginsville, Mo. (on road in $SE\frac{1}{4}NW\frac{1}{4}$ sec. 15, T. 49 N., R. 25 W.), which almost certainly came from just above the Mulky coal horizon of the Cherokee formation [and not the "Fort Scott limestone member(?) of Henrietta formation," as stated by Girty]. In addition, our collections contain one crushed but rather well-preserved testiferous specimen (John Britts Owen coll. no. 681) from the Pennsylvanian near Marietta, Fulton County, Ill., which appears to represent this species. Finally, Broadhead lists this species from just above the Mulky coal member of the Cherokee formation in the $SW\frac{1}{4}SE\frac{1}{4}$ sec. 36, T. 53 N., R. 23 W., Carroll County, Missouri, and Plummer and Scott state that it occurs in the lower Pennsylvanian at Danville, Ill., and that "fragments of similarly sculptured shells found in the Smithwick shale in McColloch County, Texas, have been tentatively referred to this genus."

Types.—The syntypes appear to have been lost. The Missouri specimen figured by Bisat, Duncan, and Moore is in the private collection of E. W. J. Moore of Rossendale, Lancashire, England; and those figured by Plummer and Scott are at the Bureau of Economic Geology of the University of Texas and the Walker Museum of the University of Chicago. All of the specimens studied by us are in the private collection of John Britts Owen, where they are numbered 672 (neoholotype, pl. 20, figs. 10, 11), 673 (pl. 20, figs. 12–14), 674 (pl. 20, figs. 15–17), 675 (text fig. 8C), and 676–682.

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A. K. MILLER, IOWA CITY, IOWA. JOHN BRITTS OWEN, CLINTON, MISSOURI. MANUSCRIPT RECEIVED BY THE EDITOR, OCTOBER 10, 1938.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 163–175, PL. 21, MARCH, 1939

OSTRACODES FROM THE MAQUOKETA SHALE, UPPER ORDOVICIAN, OF IOWA

R. C. SPIVEY

ABSTRACT—Several collections of ostracodes from the Maquoketa shale, Upper Ordovician, of Iowa are illustrated and described in this paper. Samples were studied from numerous localities in the state, and the collections obtained are believed to be representative of the formation. A few species are widespread both geographically and stratigraphically in the Maquoketa of Iowa, and sizable faunas were obtained from both the lower and middle portions of the formation; the former contains representatives of the genera *Leperditia, Aparchites, Leperditella, Primitiella, Primitia, Milleratia, Ctenobolbina, Zygobolboides, Beyrichia, Eukloedenella, Krausella, Bythocypris,* and *Ellesmeria,* and the latter, representatives of *Ctenobolbina, Warthinia, Bythocypris,* and *Macrocyproides.* Also, species referable to the genera *Bollia, Zygobolboides, Bythocypris, Macrocypris,* and *Laddella* are described from different portions of the Iowa Maquoketa.

THE Maquoketa is the youngest Ordovician formation in the Mississippi Valley region. In Iowa, it outcrops in a narrow belt extending diagonally across the northeastern corner of the state, with small inliers to the west and a possible continuation in northwestern Iowa (Tester, 1937).

In the southern portion of its outcrop in Iowa, the formation is not readily divisible into members, but in the northern portion Calvin (1906, pp. 97, 98) recognized the following four subdivisions:

> 4 *Brainard Shales.*—Blue and bluish-gray shale with some intimately associated beds of limestone at the top and bottom of the division. . . . [Named for a] small railway station in Fayette county near to which it has its most typical development. Thickness, about 120 feet.
>
> 3 *Fort Atkinson Limestone.*—Massive, yellow, cherty dolomite and associated beds of limestone . . . best exposures occurring at Fort Atkinson. Thickness, 40 feet.
>
> 2 *Clermont Shale.*—Bluish colored, plastic, fine grained shale, well developed below the Fort Atkinson limestone at Clermont in Fayette county. . . . Thickness, 15 feet.
>
> 1 *Elgin Shaly Limestones.*—Limestones, dolomites and shaly limestones with beds of calcareous shales and thin partings of bluish, less calcareous clays; quite variable in character and fossil contents, but generally yellowish, decidedly calcareous and more indurated than the blue plastic shales of 2 and 4. . . . Near Elgin the *Isotelus* beds at the base of this member are largely blue, hard, fine grained limestone. Thickness of entire member, 70 feet.

The type section of the formation is located along the Little Maquoketa River in Dubuque County, Iowa, too far south for the members just described to be recognized. In this region the formation is about 190 feet thick, and it consists largely of green or blue shale, with thin beds of limestone at the base and near the top.

In his extensive study of the Maquoketa in Iowa, Ladd (1929, pp. 370, 371) recognized a number of faunal zones, three of which persist in both the northern and southern areas of outcrop. At the base of the formation is the well-known "depauperate zone" which carries an abundance of small fossils of various types. Above this, but still in the lower portion of the formation, a graptolite fauna occurs, which may not mark precisely the same horizon in all portions of the state. Near the top of the formation comes the *Cornulites* zone, which is recognizable near both the northern and the eastern boundaries of Iowa.

In northern Iowa three faunal zones can be recognized in the Elgin member. The lowest of these occurs in the *Isotelus* beds near the base of the member; the intermediate one, in the *Vogdesia* beds, near the midportion of the Elgin; and the uppermost one, in the top of the member.

The specimens upon which this report is based were obtained from some 30 shale samples collected from all the various faunal zones in the Iowa Maquoketa. Only a few of these samples yielded identifiable ostracodes, for in most cases small fossils were composed of recrystallized calcite in which the details of the original structure had been lost. This poor preservation was particularly characteristic of the *Cornulites* zone, which

had yielded abundant mega-fossils but no well preserved ostracodes.

For stratigraphic purposes the localities from which identifiable specimens were obtained can be grouped into the following zones:

I. *"Depauperate zone:"* (1) Campus of Columbia College, Dubuque, Iowa. (2) About 200 yards west of the road which crosses Mill Creek, in the banks of the creek, just south of Bellevue, Iowa. (3) Near the line between sections 21 and 28 on the east bank of the stream which joins Turkey River in sec. 28, Clermont Township, Fayette County, Iowa.

II. *Lower Maquoketa of the southern outcrop area:* (1) Near the village of Graf, SW¼ sec. 29, T. 89 N., R. 1 E. (Center Township), Peosta Quadrangle (Dubuque County), Iowa.

III. *Vogdesia beds:* (1) South of the bridge across Roger's Creek at the eastern edge of the town of Fort Atkinson, Iowa.

IV. *Upper Elgin beds:* (1) Near the middle of the east side of sec. 19, Clermont Township, Fayette County, Iowa.

V. *Clermont shale:* (1) Road cut on highway no. 11, in the town of Eldorado, Iowa.

The most varied and best preserved collections were obtained from the lower Maquoketa at Graf and from the middle Maquoketa (Clermont shale) at Eldorado. On the basis of these collections, two distinct ostracode faunal zones can be recognized. The lower Maquoketa zone is characterized by the presence of abundant *Primitia gibbera* Ulrich, and the following new species: *Primitia bellevuensis*, *Primitiella milleri*, *Zygobolboides grafensis*, *Zygobolboides iowensis*, and *Bythocypris batesi*. The middle Maquoketa zone (Clermont shale) yielded in abundance the forms for which the names *Macrocyproides clermontensis* and *Bythocypris furnishi* are here given. A good many other species occur in both of these zones and at other horizons in the Maquoketa, but for the most part they were not found in sufficient numbers to be of appreciable value in zoning the formation.

The Maquoketa ostracode assemblages differ markedly from any previously described fauna, and consequently it is not possible to suggest any new correlations or to substantiate or disprove those that have already been made. It is hoped, however, that when other Upper Ordovician ostracode faunas have been collected and studied the affinities of the specimens here described will become apparent. Since ostracodes, because of their small size, can be obtained readily from drill cuttings, a detailed knowledge of the typical Maquoketa forms may enable us to make correlations with Paleozoic beds of uncertain affinities known to occur under the Pleistocene deposits in northwestern Iowa and adjacent portions of Minnesota, as well as with other stratigraphically equivalent beds not now exposed.

I wish to acknowledge my indebtedness to Dr. A. K. Miller for general supervision of the work and for many valuable suggestions. Dr. A. Scott Warthin has read the paper and offered many constructive criticisms, for which I am especially grateful. Also, Dr. William M. Furnish has aided greatly, especially in the preparation of the illustrations. The photographs on the accompanying plate were retouched by Mr. Howard Webster.

SYSTEMATIC PALEONTOLOGY

Genus LEPERDITIA Rouault, 1851

LEPERDITIA? DUBUQUENSIS Spivey, n. sp.

Plate 21, figures 28, 29

Valves sub-oval, with straight hinge line, which represents about one half of total length of carapace. Greatest height about one third shell length from posterior margin; greatest length at midheight or slightly above; greatest thickness in posterior third at about midheight. Carapace long and cylindrical, with a pronounced backward swing from hinge line. Nearly one fourth of valve is back of posterior end of hinge. Posterior end rather evenly rounded, and distinctly thicker than anterior end. Anterior end not as high as posterior end, and best developed above midheight. Ventral margin of right valve slightly thickened. A shallow, poorly defined depression occurs just posterior to central part of valve.

Length, width, and thickness of holotype, a right valve, 0.9 mm, 0.4 mm, and 0.2 mm, respectively.

Remarks.—This species is similar to *Aparchites? subovatus* Jones, in shape but has a post-central depression which that species lacks. A complete carapace was not found, but a thickening of the ventral margin on right valves indicates that the right valve overlaps the left.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2639.

Genus APARCHITES Jones, 1889

APARCHITES MINUTISSIMUS TRENTONENSIS Ulrich

Plate 21, figures 26, 27

Synonymy given in Bassler and Kellett's Index of Paleozoic Ostracoda (1934).

Posterior margin of carapace broadly semicircular in outline; anterior margin narrowly rounded, best developed above midheight. Greatest thickness at midheight, slightly posterior to midlength; greatest width about one third of total length from posterior end; greatest length slightly above midheight. Posterior and anterior margins meet hinge with low subequal angles. Slope from thickest part of valves to margins uniformly curved. Posterior end of valves thicker than anterior. Hinge straight and equal to about one half of total length of carapace. Margins thickened into a distinct ridge. A large, nearly circular muscle spot is present near middle of valve.

Length, width, and thickness of figured left valve, 0.80 mm, 0.53 mm, and 0.28 mm, respectively.

Remarks.—Only single valves of this variety were found, and the nature of the contact of the valves could not be determined exactly. These specimens agree well with Ulrich's (1894, p. 646) description of the species, but the valves are a little more convex. This form is rather closely related to *A. tyrellii* Jones but is somewhat narrower.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Hypotype, State Univ. Iowa, no. 2627.

Genus LEPERDITELLA Ulrich, 1894

LEPERDITELLA FRYEI Spivey, n. sp.

Plate 21, figures 14, 15

Carapace sub-oval in outline, with valves moderately convex. Greatest length slightly above midheight; greatest width in posterior half, a little behind midlength; greatest thickness at about middle of valve. Posterior end broadly and evenly rounded and a little higher than anterior end. Posterior angle more acute than anterior. Ends subequal in thickness. There is a faint, poorly defined depression in the dorsal half, slightly in front of midlength. Postero-ventral surface of depression is finely reticulate, whereas rest of surface is finely granulose. A small poorly defined node is located on anterior margin of depression. Median lobe slightly more convex than rest of valve, and set off by very faint oblique constriction on postero-ventral side and by shallow depression on antero-dorsal side. A narrow but distinct marginal border is present on all margins.

Length, width, and thickness of figured right valve, 0.80 mm, 0.44 mm, and 0.15 mm, respectively.

Remarks.—This species resembles *L. aequilatera* in outline but is smaller, has a more prominent depression on the dorsal slope, and much less convex valves. It differs from *Primitiella carli* in that the ventral margin is more evenly and gently curved, and the marginal border is distinct all around.

Occurrence.—Common in the lower Maquoketa shale at Graf, Iowa.

Types.—State Univ. Iowa, no. 2641 (one figured and three unfigured syntypes).

Genus PRIMITIELLA Ulrich, 1894

PRIMITIELLA MILLERI Spivey, n. sp.

Plate 21, figures 16, 17

Carapace sub-oval in outline. Posterior and anterior ends uniformly rounded but anterior not as high as posterior end; ventral margin almost uniformly curved. Greatest length at midheight; greatest height at midlength; greatest thickness at middle of valve. Posterior end thicker than anterior end. Anterior margin meets hinge with smaller angle than does posterior margin. Uniform slope from center to margins except at posterior end, which has a broadly rounded knob rising to a height almost equal to maximum thickness of valve. Surface very finely granulose. Hinge straight and slightly more than one half of total length of carapace. There is a broad, shallow poorly defined depression on the dorsal slope, just in front of midlength. Depression

bordered on both anterior and posterior sides by low poorly defined nodes.

Length, width, and thickness of holotype, a right valve, 0.70 mm, 0.40 mm, and 0.12 mm, respectively.

Remarks.—This species is closely related to *P. ulrichia*, but differs in having a depression on the dorsal slope. It can be distinguished from *P. unicornis* in that it has (1) a less conspicuous straight hinge, (2) a far more deeply impressed sulcus, and (3) a blunt knob rather than a sharp spine. The presence of the low nodes bordering the sulcus seems to indicate a rather close relationship to the genus *Ulrichia*.

Occurrence.—Common in the lower Maquoketa at Graf and Bellevue, Iowa. Rare in the *Vogdesia* beds of the lowerMaquoketa at Fort Atkinson, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2612, from Graf; four paratypes, no. 2640 from Graf; three paratypes, no. 2613, from Bellevue; one paratype, no. 2614, from Ft. Atkinson.

PRIMITIELLA CARLI Spivey, n. sp.

Plate 21, figures 9, 10

Sub-ovate in outline; valves moderately convex. Greatest length at midheight or slightly above; greatest height slightly posterior to midlength; greatest thickness at about middle of valve; posterior end a little thicker than anterior end. Posterior end broadly, but irregularly, rounded. Anterior end more acuminate, unequally rounded, best developed at midheight. Posterior angle slightly more acute than anterior, but with no backward swing to the carapace. There is a shallow, poorly defined depression on dorsal slope, a little in front of midlength. Depression broad at dorsal margin, narrowing at ventral end, and curving slightly forward. Low, poorly defined node on anterior side of depression.

Length, width, and thickness of figured right valve, 0.60 mm, 0.35 mm, and 0.10 mm, respectively.

Remarks.—This species differs from *P. simulans*, which it closely resembles, in that the anterior end is more acuminate and best developed at, rather than above, midheight. It differs from *P. constricta* in that the ventral margin is more strongly curved, and the marginal border is indistinct or lacking.

Occurrence.—Rare in the "depauperate zone" of the lower Maquoketa shale at Bellevue, Iowa.

Types.—Syntypes, State Univ. Iowa, no. 2624 (2 specimens).

Genus PRIMITIA Jones and Holl, 1865

PRIMITIA GIBBERA Ulrich

Plate 21, figures 7, 8

Carapace sub-oval; valves moderately convex. Greatest length a little above midheight; greatest height about one third of total length of valve from posterior margin; greatest thickness in dorsal half at about midlength. Posterior end broadly and evenly rounded. Posterior angle larger than anterior, and posterior end considerably higher than anterior. Hinge straight, a little more than one third of length of valves. Sulcus short, rather shallow, with low node on anterior side, which gives antero-dorsal surface a gibbous appearance. Sulcus about one third of length of valve from anterior margin. Marginal border wide, but not distinctly marked off from rest of valve.

Length, width, and thickness of figured right valve, 0.85 mm, 0.58 mm, and 0.20 mm, respectively.

Remarks.—The specimens studied differ from *P. gibbera*, as described by Ulrich (1894, p. 655) only in the presence of the indistinct marginal border. The presence or absence of this border may be due to a difference in preservation, rather than to an essential difference in the specimens.

Occurrence.—Fairly common in the "depauperate zone" of the lower Maquoketa shale at Bellevue, Iowa.

Types.—Hypotypes, State Univ. Iowa, no. 2617 (1 figured and 4 unfigured specimens).

PRIMITIA BELLEVUENSIS Spivey, n. sp.

Plate 21, figures 20, 21

Outline of carapace sub-ovate; greatest length at midheight; greatest height at midlength; greatest thickness slightly above midheight and posterior to midlength. Hinge straight, slightly less than one half of total length of carapace. Posterior margin meets hinge at a greater angle than does

anterior margin. Anterior end more narrowly rounded than posterior and extends beyond hinge to a greater distance than does posterior end, giving carapace a forward swing. Sulcus located just anterior of midlength and deepest ventrally, with deepest part sub-triangular in shape, the triangular part connected to dorsal margin by a shallow depression which curves slightly toward posterior. Valves strongly convex; slope from middle of valves to margins steepest on ventral and dorsal sides and gentlest on posterior end. Surface of carapace smooth. Marginal border very narrow. Median lobe poorly defined and represented by a swelling just posterior to sulcus.

Length, width, and thickness of holotype, a left valve, 0.83 mm, 0.52 mm, and 0.26 mm, respectively.

Remarks.—This species is closely related to *P. impressa* Ulrich of the Maquoketa of Indiana and Illinois, but differs in having the sulcus farther forward, the hinge line longer, and the posterior margin more broadly rounded.

Occurrence.—Fairly common in the "depauperate zone," lower Maquoketa shale, at Bellevue, Iowa, and rare in the same zone at Dubuque, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2618, from Bellevue; two paratypes, no. 2619, from Bellevue; one paratype, no. 2620, from Dubuque.

Genus MILLERATIA Swartz, 1936

MILLERATIA CINCINNATIENSIS (Miller)

Plate 21, figures 18, 19

Ends approximately equal in thickness; anterior end broadly and evenly rounded; posterior end more narrowly rounded with prominent backward swing. Maximum length slightly below midheight; maximum height about one third of total length of valve from posterior end; maximum thickness on dorsal third of valve at about midlength. Median lobe represented by swelling on posterior side of sulcus. Posterior lobe overhangs posterior end of hinge. Hinge straight, short, about half total length of carapace. Sulcus in dorsal half of valve, just in front of midlength; deep; widest at ventral end; not extending to dorsal border; and with longest diameter at right angles to hinge. Node on anterior side of sulcus round, high, and well-defined. Surface finely granulose.

Length, width and thickness of figured right valve, 0.73 mm, 0.50 mm, and 0.22 mm, respectively.

Occurrence.—Rare in the "depauperate zone" of the lower Maquoketa shale at Bellevue, Iowa.

Types.—Hypotype, State Univ. Iowa, no. 2611.

Genus WARTHINIA Spivey, n. gen.

Small equivalved Ostracoda with long, straight hinge, finely reticulate surface and more or less distinct border. Primarily with four, but sometimes only three, nodes; one node located on each side of short sulcus, and other node (or nodes) on postero-ventral and ventral surface. The genus shows some variation in the development of ornamentation, some specimens having relatively weak nodes and border, while others have much heavier borders, and spines on the nodes.

Gentotype, *Ulrichia nodosa* Ulrich.

This genus differs from *Ulrichia* in that it has finer reticulations and more than two nodes on the surface of the test.

WARTHINIA NODOSA (Ulrich)

Plate 21, figures 3–6

Carapace semicircular in outline; equivalved; ends of equal height and thickness. Greatest length in dorsal third; greatest height at midlength; greatest thickness (exclusive of spine) in posterior third at about midheight. Hinge straight and about five sevenths of length of carapace. Marginal ridge relatively wide and thick. Sulcus shallow, slightly behind midlength, extending from dorsal margin to about one third width of valve. Spine rising from anterior side of sulcus, projecting laterally and dorsally slightly beyond hinge line. Round, sharply defined node on posterior side of sulcus. Two and sometimes three poorly defined, low nodes on postero-ventral and ventral slopes. Surface finely reticulate.

Length, width, and thickness of figured right valve, 0.60 mm, 0.27 mm, and 0.20 mm, respectively.

Remarks.—The spine and the nodes are hollow, and internal molds of the valves

closely resemble illustrated specimens of *Warthinia nodosa*.

Occurrence.—Common in the Clermont shale member of the Maquoketa at Eldorado, Iowa, and in the lower Maquoketa at Graf, Iowa.

Types.—Hypotypes, State Univ. Iowa, no. 2636, seven specimens from Eldorado; no. 2634, two specimens from Graf.

Genus CTENOBOLBINA Ulrich, 1890

CTENOBOLBINA EMACIATA (Ulrich)

Plate 21, figures 30, 31

Sub-ovate in outline; valves strongly convex. Greatest length slightly above midheight; greatest width at midlength; greatest thickness through median lobe at about middle of valve. Posterior lobe rounded; median lobe prominent and oblique; anterior lobe relatively wide and short. Posterior sulcus deep and very wide on dorsal half of valve, divided dorsally by slight elevation; anterior sulcus narrow and oblique. Flange on ventral slope wide, smooth except for granulations at edge. Hinge long and straight. Anterior, ventral, and posterior margins spinose. Surface granulations closely crowded.

Length, width, and thickness of figured right valve, 1.80 mm, 0.80 mm, and 0.55 mm, respectively.

Remarks.—Only one specimen, an imperfect right valve, of this species was found. This specimen is similar to those described by Ulrich from the Maquoketa of Illinois, except that it is a little narrower.

Occurrence.—Rare in the Clermont shale member of the Maquoketa at Eldorado, Iowa.

Type.—Hypotype, State Univ. Iowa, no. 2628.

CTENOBOLBINA MAQUOKETENSIS

Spivey, n. sp.

Plate 21, figures 32, 33

Carapace sub-oval in outline. Greatest length at about midheight; greatest width at about midlength; greatest thickness in posterior third of carapace at about midheight. Sulcus extending from mid-dorsal margin about two thirds across valve, deepest in dorsal half; bordered on anterior side by round prominent node. Anterior half of valve moderately convex; posterior half strongly convex. Posterior side of sulcus rising steeply to thickest part of valve; the posterior surface slightly overhanging posterior margin. Narrow marginal ridge most distinct on posterior and ventral margins. Low rounded node on postero-dorsal slope. Hinge straight, about two thirds of total length of the valve. Surface coarsely papillose.

Length, width, and thickness of holotype, a right valve, 0.63 mm, 0.40 mm, and 0.20 mm, respectively.

Remarks.—This species differs from *Ctenobolbina tumida* in that the median sulcus is wider, the flange not crenulate, the anterior lobe not forming a distinct ridge along the antero-ventral surface, the median lobe more rounded, and a node occurs on the postero-dorsal surface. It differs from *Entomis madisonensis* in that the thickest part of the carapace is farther back, and there is a much steeper slope from the thickest part of the valves to the posterior margin and a less abrupt slope from the thickest part down to the sulcus. The holotype probably represents a young moult.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2635.

Genus BOLLIA Jones and Holl, 1886

BOLLIA RUTHAE Spivey n. sp.

Plate 21, figures 34, 35

Sub-quadrate in outline; valves moderately convex. Anterior end highest; postero-dorsal angle more nearly acute than anterior marginal angle, giving the carapace a backward swing. Greatest length slightly above midheight; greatest height at about midlength. Posterior lobe strongly developed and extends from postero-dorsal angle almost to postero-ventral margin. Median and anterior lobes united ventrally into a U-shaped loop. Upper ends of loop project slightly beyond hinge, and ventral part of loop overhangs and projects a little beyond ventral margin. Maximum thickness is through these lobes at about midheight of shell. Anterior-anterior lobe less strongly developed than posterior lobe, and extends from hinge to ventral margin.

Median sulcus long; deeper and wider than the other two. Hinge long, straight and about five sixths length of valve. Surface of valves finely granular.

Length, width, and thickness of holotype, a left valve, 0.54 mm, 0.30 mm, and 0.20 mm, respectively.

Remarks.—This species is closely related to *Bollia regularis* but the loop extends farther, both ventrally and dorsally. It differs further in that the carapace has a more distinct backward swing, and in that the posterior rather than the anterior-anterior lobe is the better developed of the two.

Occurrence.—Common in the "depauperate zone" of the lower Maquoketa shale at Clermont, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2625; paratypes (three) no. 2626.

Genus ZYGOBOLBOIDES Spivey, n. gen.

Tri-lobed, emaciated-appearing Zygobolbinae, somewhat smaller than the average of that subfamily. The lobes have broad bases, which are surmounted by thin, crestlike ridges. Typically, the bases of the anterior and median lobes are indistinctly united ventrally.

Genotype, *Zygobolboides grafensis* Spivey, n. sp.

Remarks.—The genus differs from *Zygobolba*, which it resembles rather closely, in that (1) its posterior lobe is well developed; (2) no marginal border is present; (3) lobes are indistinctly united below, if at all; (4) no brood pouch was found on any of the 20 or more specimens studied; (5) the median lobe is not inflated; and (6) the average size of the specimens is smaller than in *Zygobolba*.

This genus differs from such representatives of *Beyrichia* as *B. buchiana* in that the median lobe is larger than the posterior lobe; the median lobe is joined to the anterior rather than to the posterior lobe, and there is no spinose marginal ridge. Also, in this genus the lobes are thin and crestlike, rather than broadly rounded as in the *Zygobeyrichia*.

ZYGOBOLBOIDES GRAFENSIS Spivey, n. sp.
Plate 21, figures 42, 43

Sub-quadrate in outline; anterior end slightly thicker and not as high as posterior end. Greatest length at midheight; greatest height in posterior third; greatest thickness at median lobe in approximate center of valve. Tri-lobed. Anterior lobe curved subparallel to anterior margin and capped by a thin crestlike ridge; the lobe, but not the crest, swollen near the dorsal end. Median lobe prominent, vertical in dorsal fourth, then curving first forward and then ventrally to make a sigmoidal curve in the lower half. Bases of anterior and median lobes broadly united ventrally, but crests not united. Posterior lobe well developed and longer but not as thick as anterior lobe. All lobes extend about four fifths of distance between dorsal and ventral borders. Posterior sulcus broad and deep, extending from dorsal to ventral margins, widening toward the venter. Median sulcus deeper than posterior sulcus, about the same width dorsally but becoming narrower ventrally; it is curved toward the anterior end in the dorsal half, but almost vertical at the ventral end. Hinge straight, about 0.7 total length of valve. Ventral margin nearly straight but not parallel to hinge.

Length, width, and thickness of holotype, a right valve, 0.85 mm, 0.50 mm, and 0.20 mm, respectively.

Remarks.—This species differs from *Z. iowensis* in that the median lobe is not as thick, and is sigmoidally curved in the ventral half. Also, the posterior lobe is better developed, and all lobes are longer. The species differs from *Z. thomasi* in that the lobes are narrower and less bulbous, and the anterior lobe is semicircular rather than sigmoidally curved. It differs from *Z. calvini* in that the crests surmounting the lobes are not as uniform in thickness and not as straight.

Occurrence.—Common in the lower Maquoketa shale at Graf, Iowa, and present in the "depauperate zone" of the lower Maquoketa at Bellevue and Dubuque, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2602, from Graf; 7 paratypes from Graf, no. 2603; 2 paratypes from Bellevue; no. 2604; 2 paratypes from Dubuque, no. 2605.

ZYGOBOLBOIDES IOWENSIS Spivey, n. sp.
Plate 21, figures 44–46

Sub-oval in outline; posterior margin

meets hinge at a smaller angle than does anterior margin; also posterior margin is more broadly rounded, giving the carapace a slight backward swing. Hinge straight, about three fifths length of valve. Greatest length slightly above midheight; greatest height at midlength or slightly posterior to it; greatest thickness through median lobe at about middle of carapace. Ventral margin is gently curved, with middle portion nearly straight and sub-parallel to hinge. Anterior lobe gently curved and sub-parallel to anterior margin. Median lobe vertical in dorsal third of valve, then curving forward. Crests of both of these lobes are rather thin and distinct. Base of median lobe is broad and occupies about one fourth total area of valve. Posterior lobe well developed in ventral half of valve, but gradually disappears on ventral slope. Median sulcus very deep and vertical on dorsal fourth of valve, then curves anteriorly; relatively shorter and rounder than *Z. thomasi* and *Z. grafensis*. The posterior sulcus is very nar-

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EXPLANATION OF PLATE 21

All specimens illustrated are from the Maquoketa shale in northeastern Iowa; all figures ×25.

FIGS. *1, 2—Beyrichia irregularis* Spivey, n. sp. Lateral and dorsal views of a right valve, the holotype. (p. 172)

3–6—Warthinia nodosa (Ulrich). *3, 4,* Lateral and dorsal views of a right value. *5, 6,* Dorsal and lateral views of an internal mold of a right valve. (p. 167)

7, 8—Primitia gibbera Ulrich. Lateral, and ventral views of a right valve. (p. 166)

9, 10—Primitiella carli Spivey, n. sp. Ventral and lateral views of a right valve, syntype. (p. 166)

11–13—Macrocypris kayi Spivey, n. sp. Internal, dorsal, and lateral views of a right valve, the holotype. (p. 173)

14, 15—Leperditella fryei Spivey, n. sp. Lateral and dorsal views of a right valve, syntype. (p. 165)

16, 17—Primitiella milleri Spivey, n. sp. Dorsal and lateral views of a left valve, the holotype. (p. 165)

18, 19—Milleratia cincinnatiensis. Lateral and dorsal views of a right valve. (p. 167)

20, 21—Primitia bellevuensis Spivey, n. sp. Ventral and lateral views of a right valve, the holotype. (p. 166)

22, 33—Eukloedenella richmondensis Spivey, n. sp. Lateral and ventral views of holotype. (p. 172)

24, 25—Krausella inaequalis Ulrich? Lateral and dorsal views of a right valve. (p. 172)

26, 27—Aparchites minutissimus trentonensis Ulrich. Lateral and ventral views of a left valve. (p. 165)

28, 29—Leperditia? dubuquensis Spivey, n. sp. Lateral and ventral views of a right valve, holotype. (p. 164)

30, 31—Ctenobolbina emaciata (Ulrich). Lateral and ventral views of a right valve. (p. 168)

32, 33—Ctenobolbina maquoketensis Spivey, n. sp. Lateral and dorsal views of a left valve, the holotype. (p. 168)

34, 35—Bollia ruthae Spivey, n. sp. Lateral and ventral views of a left valve, the holotype. (p. 168)

36, 37—Bythocypris furnishi Spivey, n. sp. Right lateral view and dorsal view of an entire carapace, a syntype. (p. 173)

38, 39—Macrocyproides clermontensis Spivey, n. sp. Lateral view of left valve and dorsal view of entire carapace, a syntype. (p. 174)

40, 41—Ellesmeria scobeyi Spivey, n. sp. Lateral view of left valve and dorsal view of entire carapace, the holotype. (p. 175)

42, 43—Zygobolboides grafensis Spivey, n. sp. Ventral and lateral views of a right valve, the holotype. (p. 169)

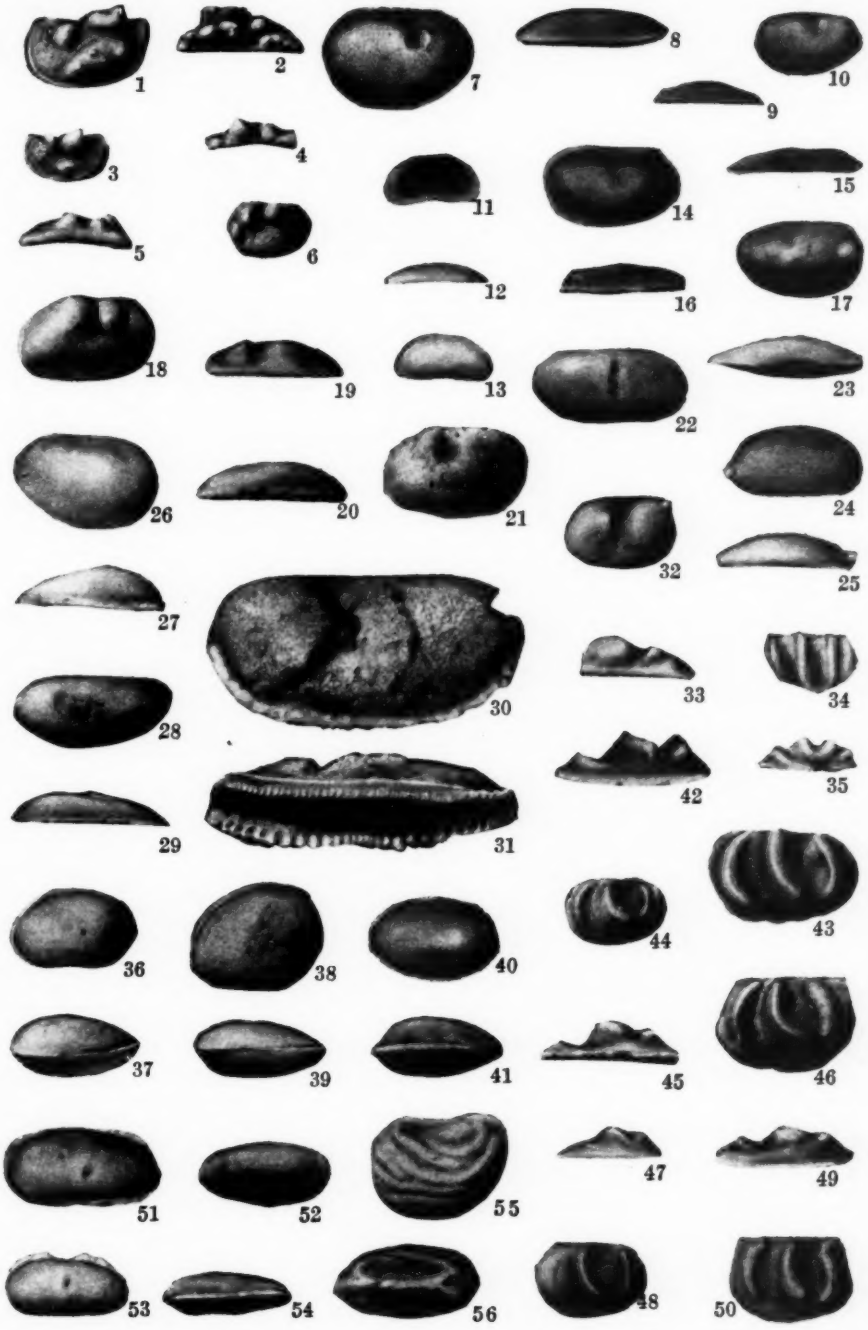
44–46—Zygobolboides iowensis Spivey, n. sp. *44,* Lateral view of right valve of a small paratype. *45, 46,* Ventral and lateral views of right valve of a specimen of average size, the holotype. (p. 169)

47, 48—Zygobolboides calvini Spivey, n. sp. Ventral and lateral views of a right valve, the holotype. (p. 171)

49, 50—Zygobolboides thomasi Spivey, n. sp. Ventral and lateral views of a right valve, the holotype. (p. 171)

51–54—Bythocypris batesi Spivey, n. sp. *51,* Lateral view of right valve of a large syntype. *52,* Left valve of syntype with curved ventral margin. *53, 54,* Lateral and ventral views of an average syntype. (p. 173)

55, 56—Laddella insueta Spivey, n. sp. Lateral view of right valve and dorsal view of entire carapace, the holotype. (p. 174)



Spivey, Ordovician Ostracoda

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row at the top, widening and shallowing below; in general much narrower and shallower than in *Z. thomasi* and *Z. grafensis*.

Length, width, and thickness of holotype, a right valve, 0.80 mm, 0.55 mm, and 0.30 mm, respectively.

Remarks.—This species differs from *Z. thomasi* in that the anterior lobe is semicircular; the median lobe is better developed and higher, with crest more distinct; the median sulcus is deeper and the posterior sulcus is narrow and poorly developed because the median lobe is very broad. It differs from *Z. grafensis* in that the median lobe is broader and relatively thicker, the posterior lobe is not as well developed, and all lobes are shorter. The species differs from *Z. calvini* in that all the lobes are broader, the posterior lobe is better developed, and the crests surmounting the lobes are not as straight or as uniform in thickness.

Occurrence.—Rare in the lower Maquoketa shale at Graf and Clermont, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2609, from Graf; paratype from Clermont, no. 2610.

ZYGOBOLBOIDES THOMASI Spivey, n. sp.
Plate 21, figures 49, 50

Sub-quadrate in outline; posterior end slightly higher; posterior and anterior angles about equal. Hinge straight, about three fourths total length of valve. Greatest length at about midheight; greatest height slightly posterior to midlength; greatest thickness through median lobe at about midheight and just anterior to midlength. Anterior lobe sigmoidally curved with axis of curve slightly above middle of lobe, upper end being curved forward and lower end curved backward. Crest broader and less distinct than in *Z. grafensis;* base of lobe broader at ventral end. Median lobe at right angles to hinge in dorsal fourth of valve, but curving toward anterior end of valve in ventral part of lobe and becoming broad and bulbous at the ventral end, with the base uniting with base of anterior lobe. Crest broad and less distinct than in *Z. grafensis.* Posterior lobe well developed in dorsal half of carapace, disappearing gradually below. All lobes extend about three fourths of distance across valve from dorsal margin. Median sulcus deep; curved forward at ventral end and extended about one third distance across valve. Posterior sulcus shallower, extending entirely across valve; broadening toward venter.

Length, width, and thickness of holotype, a right valve, 0.7 mm, 0.40 mm, and 0.15 mm, respectively.

Remarks.—This species differs from *Z. grafensis* in that the lobes are broader and shorter; the median lobe is bulbous ventrally rather than sigmoidally curved; the anterior lobe is sigmoidal rather than semicircular; the median sulcus is shorter; the posterior lobe is less well developed; and the posterior height is relatively less. It differs from *Z. iowensis* and *Z. calvini* in that the anterior and median lobes are more bulbous at the ventral end, the anterior lobe is sigmoidal rather than semicircular, and the three lobes are more nearly equal in size.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2608.

ZYGOBOLBOIDES CALVINI Spivey, n. sp.
Plate 21, figures 47, 48

Sub-quadrate in outline; hinge straight, about half the length of the valve; posterior angle slightly larger, giving carapace a slight forward swing. Greatest length slightly above midheight; greatest height in posterior third of carapace; greatest thickness at about middle of valve; anterior half of valve thicker than posterior half. Anterior lobe surmounted by a thin crest, which is slightly curved posteriorly at both ends, but essentially straight in the middle. Median lobe curves gently, its ends pointing slightly forward. Posterior lobe strongly developed, with thin crest and broad base; it is long, narrow, low and parallel with posterior margin. Median sulcus wide and somewhat barrel-shaped; it is relatively shallow, with a very slight forward swing at ventral end. Posterior sulcus narrow, shallow, and curved parallel with posterior lobe.

Length, width and thickness of holotype, a right valve, 0.58 mm, 0.38 mm, and 0.21 mm, respectively.

Remarks.—This species differs from *Z. grafensis, Z. thomasi,* and *Z. iowensis* in having very thin crestlike ridges on the

lobes, much thinner than in the other known congeneric species, and in having the crests relatively straighter and more nearly equal in thickness throughout their entire length.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2606; paratype, no. 2607.

Genus BEYRICHIA McCoy, 1844

BEYRICHIA IRREGULARIS Spivey, n. sp.

Plate 21, figures 1, 2

Carapace sub-quadrate in outline. Posterior angle smaller than anterior, and posterior end higher than anterior, which gives carapace a backward swing. Greatest length at midheight; greatest width (hinge to venter) just behind midlength. Anterior end thicker than posterior. Hinge straight, about seven eighths of total length of carapace. A narrow but distinct flange on ventral slope is farthest from ventral margin at mid-venter, as it slopes toward and merges with margin at antero-ventral and postero-ventral edges. Sulcus narrow and shallow; extending one third to one half width of valve from dorsal margin, just behind midlength. Sulcus bordered on both sides by nodes. Anterior node much larger: somewhat elongate parallel to hinge; with low spine projecting from anterior part of node, and extending laterally and dorsally beyond hinge line. Posterior node low and rounded, best defined on side toward sulcus. A large prominent lobe on ventral surface extends from just below anterior node obliquely back to postero-ventral quarter; the lobe and the postero-ventral fourth of valve coarsely granular, with 12 to 15 small nodes on the surface. Surface of other parts of carapace finely granular. Free margins thickened into a narrow ridge.

Length, width, and thickness of holotype, a right valve, 0.70 mm, 0.40 mm, and 0.28 mm, respectively.

Remarks.—This species is rather closely related to *B. tuberculata*, but differs in that its anterior lobe is more prominent and more sharply defined and its sulcus is much shorter.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Types.—Holotype, State Univ. Iowa, no. 2631; paratype, no. 2632.

Genus EUKLOEDENELLA Ulrich and Bassler, 1923

EUKLOEDENELLA RICHMONDENSIS Spivey, n. sp.

Plate 21, figures 22, 23

Carapace elongate-oval. Both ends unevenly curved; anterior end best developed above midheight; posterior end best below midheight; anterior angle more rounded than posterior angle. Posterior end slightly thicker than anterior end. Greatest length at about midheight; greatest height in anterior third; greatest thickness slightly posterior to midlength at about midheight. Sulcus very shallow at mid-dorsal margin, but becomes deeper near middle of valve and disappears a little below midheight. A broad shallow depression on ventral slope gives a slight arch to mid-ventral margin. Hinge line straight, the hinge being about seven elevenths of the length of the carapace.

Length, width, and thickness of holotype, 0.78 mm, 0.4 mm, and 0.26 mm, respectively.

Remarks.—This species is based on a single specimen which represents the left valve and a crushed right valve. It differs markedly from most described species but is evidently somewhat related to the *Eukloedenella umbilicata* group, as distinguished by Ulrich and Bassler (1923, p. 669).

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2633.

Genus KRAUSELLA Ulrich, 1894

KRAUSELLA INAEQUALIS Ulrich?

Plate 21, figures 24, 25

At least right valve is reniform, with ventral margin nearly straight and dorsal margin evenly and moderately arched. Ends equally rounded and of equal thickness. Greatest length is in ventral third of valve; greatest width at about midlength, and greatest thickness in ventral third. The most prominent part of the posterior end of the right valve is projected into a short round spine. The surface of the valve is smooth except for an oval muscle spot with

reticulate markings on the mid-dorsal slope.

Length, width, and thickness of figured right valve, 0.78 mm, 0.37 mm, and 0.18 mm, respectively.

Remarks.—This species differs from *K. arcuata* in that its ends are more blunt, and the ventral part of at least the right valve is much thicker than the dorsal.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Types.—Hypotypes (two), State Univ. Iowa, no. 2630.

Genus BYTHOCYPRIS Brady, 1880

BYTHOCYPRIS BATESI Spivey, n. sp.

Plate 21, figures 51–54

Carapace sub-oval in outline; valves strongly convex, with left valve larger and overlapping the right valve on dorsal and ventral margins. Greatest length slightly below midheight; greatest height in posterior half, a little behind midlength; greatest thickness typically in posterior third. Posterior end narrowly rounded; anterior end more acuminate. Dorsal margin moderately arched; ventral margin straight or slightly curved. Shallow circular pit on right valve near middle of valve.

Length, width, and thickness of a typical specimen (plate 21, figs. 53, 54), 0.70 mm, 0.35 mm, and 0.20 mm, respectively.

Remarks.—Closely related to *B. granti*, but differs in that the ventral half of carapace is not noticeably thicker than the dorsal half. Related to *B. cylindrica*, but differs in that the posterior half of the carapace is relatively lower.

The curvature of the ventral margin is variable; in some specimens the venter is straight and in others it is curved. The position of greatest thickness of the carapace varies also, from just behind midlength in some specimens to the posterior fourth of the valves in others. Since all gradations between the extremes may be found, it is probable that only one species is represented.

Occurrence.—Very abundant in the lower Maquoketa shale at Graf and Dubuque, Iowa.

Types.—State Univ. Iowa, no. 2621 (numerous syntypes from Graf), and no. 2623 (numerous syntypes from Dubuque).

BYTHOCYPRIS FURNISHI Spivey, n. sp.

Plate 21, figures 36, 37

Outline of carapace subreniform; valves moderately convex, with left valve larger and overlapping right on all margins except antero-dorsal. Anterior margin broadly and evenly rounded; posterior margin more acuminate and best developed below midheight. Dorsal margin evenly and moderately arched; ventral margin is slightly concave. Greatest length in ventral third of carapace; greatest height in posterior half; and greatest thickness in anterior third. Surface of valves smooth.

Length, width, and thickness of figured specimen, 0.72 mm, 0.42 mm, and 0.32 mm, respectively.

Remarks.—In shape this species is quite similar to *Bythocypris siliqua* (Jones), but the position of greatest width is anterior in *B. furnishi* rather than posterior. The species differs from *Macrocyproides clermontensis* in that it is narrower, the ventral margin is concave, and the greatest width is farther toward the anterior. The unequal ends make this species easily distinguishable from *Macrocyproides curtus*.

Occurrence.—Abundant in the upper part of the Clermont shale member of the Maquoketa at Eldorado, Iowa.

Types.—Syntypes (15), State Univ. Iowa, no. 2615.

Genus MACROCYPRIS Brady, 1867

MACROCYPRIS KAYI Spivey, n. sp.

Plate 21, figures 11–13

Carapace sub-reniform in outline. Dorsal margin unevenly arched, becoming straight for a short distance at midlength. Ventral margin strongly arched. Ends equal in thickness; posterior somewhat more broadly rounded than anterior end. Greatest length in ventral third; greatest width on both sides of midlength at about one third length of valve from the two ends. Mid-dorsal and mid-ventral areas slightly depressed; depression not extending to middle of valve. Inside of right valve has thin platform at both ends and along ventral side; platform widest at ends, very narrow ventrally. Surface smooth. Valves thin and delicate.

Length, width, and thickness of holotype,

a right valve, 0.40 mm, 0.24 mm, and 0.07 mm, respectively.

Remarks.—This species resembles *M. vinei* Jones somewhat, but is shorter and has blunter ends.

Occurrence.—Rare in the "depauperate zone" of the lower Maquoketa shale near Clermont, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2629.

Genus MACROCYPROIDES Spivey, n. gen.

Carapace reniform or sub-oval; moderately to strongly convex; valves unequal, with the right valve larger and overlapping the left on all margins except the postero-dorsal, where the margins may be equal or the overlap reversed. Dorsal margin arched, ventral margin straight or concave. Posterior end more broadly rounded and thicker than anterior.

Genotype, *Macrocyproides clermontensis* Spivey, n. sp.

Remarks.—This genus differs from *Bythocypris* in that the overlap of the valves is reversed. It differs from *Macrocypris* in being much wider and blunter in outline.

The form from the midportion of the "Trenton" at St. Paul, Minn., which Ulrich described in 1897 as *Bythocypris? curta*, probably belongs in this genus. *Macronotella? rectangularis* Ulrich and *Leperditella minuta* Tolmachoff probably belong here also.

MACROCYPROIDES CLERMONTENSIS
Spivey, n. sp.
Plate 21, figures 38, 39

Carapace short; sub-ovate; valves moderately convex, with right valve larger and overlapping left on all margins except postero-ventral where the margins are equal or the overlap slightly reversed. Posterior margin broadly and evenly rounded; anterior margin broadly rounded, best developed below midheight. Anterior end not as high or as thick as posterior end. Dorsal margin strongly arched; ventral margin straight. The greatest length is at about midheight; the greatest width is in the posterior third. Surface smooth.

Length, width, and thickness of figured specimen, 0.73 mm, 0.60 mm, and 0.35 mm, respectively.

Remarks.—This species is much wider and blunter than *Bythocypris furnishi* and has the greatest width farther toward the posterior margin; also, the ventral margin is straight rather than concave.

Occurrence.—Fairly common in the Clermont shale member of the Maquoketa at Eldorado, Iowa.

Types.—Syntypes (2), State Univ. Iowa, no. 2616.

Genus LADDELLA Spivey, n. gen.

Small, nearly equivalved Ostracoda with short straight hinge. All margins thickened into broad low carina, which parts posterior to hinge, leaving a small circular pit. Anterior part of carapace extending dorsally beyond hinge line. Surface of valves marked by broad, rounded, longitudinal ridges, most of which curve dorsally at both ends

Genotype, *Laddella insueta* Spivey, n. sp.

Remarks.—Only one specimen of the genus was found, and its affinities are uncertain, for it differs markedly from any previously described form known to me. Warthin (personal communication, May 23, 1938) has even suggested that this may not be an ostracode.

LADDELLA INSUETA Spivey, n. sp.
Plate 21, figures 55, 56

Carapace sub-reniform in outline, strongly biconvex. Greatest length in dorsal half; greatest width at about midlength; greatest thickness at about middle of valve. Posterior end thicker than anterior end. Posterior margin broadly and evenly curved. Anterior end best developed in dorsal third and extending dorsally beyond hinge. Hinge straight, about one third length of carapace. Equivalved, with all margins thickened into a broad low carina. Carina parts just posterior to hinge, leaving small circular pit involving both valves. Entire surface, including carina, finely reticulate. Broad shallow depression located on mid-dorsal slope. Carapace further marked by broad, rounded, longitudinal ridges, most of which curve dorsally at both ends.

Length, width, and thickness of holotype, 0.83 mm, 0.60 mm, and 0.42 mm, respectively.

Occurrence.—Rare in the upper Elgin

beds of the Maquoketa shale near Clermont, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2637.

Genus ELLESMERIA Tolmachoff, 1926

ELLESMERIA SCOBEYI Spivey, n. sp.

Plate 21, figures 40, 41

Carapace sub-oval in outline; valves thick and strongly convex. Right valve larger and overlapping left. Dorsal and ventral margin almost evenly curved; posterior end more broadly rounded and thicker than anterior end. Greatest length is at midheight; greatest height at midlength; greatest thickness in the posterior half at about midheight. Surface finely punctate.

Length, width, and thickness of holotype, 0.73 mm, 0.47 mm, and 0.34 mm, respectively.

Remarks.—This form is quite similar to *E. ovata* Tolmachoff, but inasmuch as all of the known representatives of that species, came from the Devonian of Ellesmereland whereas the type specimen of *E. scobeyi* came from the Ordovician of Iowa, they probably are not conspecific. *Ellesmeria scobeyi* differs from *Bythocypris concinna ovalis* Jones in that the thickest part of the carapace is a little farther toward the rear, the outline is a little broader, and the shell is thicker.

Occurrence.—Rare in the lower Maquoketa shale at Graf, Iowa.

Type.—Holotype, State Univ. Iowa, no. 2638.

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CLAIBORNE EOCENE SPECIES OF THE OSTRACODE GENUS CYTHEROPTERON

JAMES L. MARTIN

ABSTRACT.—Five new species of *Cytheropteron* and one species doubtfully assigned to this genus are described and figured. These forms occur in the Claiborne group, upper middle Eocene, of the Gulf coastal region. Importance of stratigraphic ranges of both the new and previously described species is dealt with.

THE genus *Cytheropteron* was first described zoologically from Recent material in Norway by Sars (1865). It was redescribed by Alexander (1933) on the basis of structure of the carapace.

In the present paper five new species; *C. lisbonense*, *C. spinosum*, *C. variosum*, *C. proboscense*, and *C. incertum* are described from Claiborne beds of the Eocene series of the Gulf Coast. One doubtful species, *C.? fragillissimum*, has also been assigned to the genus *Cytheropteron*. The only previous paper describing Gulf Coast Claiborne ostracodes, by Stadnichenko (1927), lists one species of *Cytheropteron* which can now be placed in the genus *Brachycythere* Alexander (1933).

Some of the species described in the present paper are similar to those already described by Alexander from the Cretaceous (1929, 1933) and the Midway (1934); by Howe and Chambers from the Jackson Eocene (1935); and by Howe and Law from the Vicksburg Oligocene (1936). Yet all of them possess enough differences to warrant new specific determination. In pursuing the present investigation it was found that all the described Cretaceous and Tertiary species, as well as those under present study, possess a narrow stratigraphic range. Assuming no error in this work, these species are good markers for their various horizons. The species are as follows:

Vicksburg Oligocene
- *Cytheropteron galericum* Howe and Law, 1936

Jackson Eocene
- *Cytheropteron danvillense* Howe and Chambers, 1935
- *Cytheropteron montgomeryense* Howe and Chambers, 1935

Claiborne Eocene
- *Cytheropteron lisbonense* Martin, n. sp.
- *Cytheropteron spinosum* Martin, n. sp.
- *Cytheropteron variosum* Martin, n. sp.
- *Cytheropteron proboscense* Martin, n. sp.
- *Cytheropteron incertum* Martin, n. sp.
- *Cytheropteron? fragillissimum* Martin, n. sp.

Midway Eocene
- *Cytheropteron midwayense* Alexander, 1934
- *Cytheropteron aligerum* Alexander, 1934

Cretaceous
- *Cytheropteron acutolatum* Alexander, 1929
- *Cytheropteron navarroense* Alexander, 1929
- *Cytheropteron rugosalatum* Alexander, 1929
- *Cytheropteron bicornutum* Alexander, 1933
- *Cytheropteron israelskyi* Alexander, 1933
- *Cytheropteron wenoense* Alexander, 1933
- *Cytheropteron eximum* Alexander, 1933
- *Cytheropteron furculatum* Alexander, 1933
- *Cytheropteron blakei* Alexander, 1933

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All type materials are deposited in the Henry V. Howe Collection, Department of Geology, Louisiana State University.

Order OSTRACODA Latreille

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird, 1850

Genus CYTHEROPTERON Sars, 1865

Subgenus CYTHEROPTERON Sars, s.s.

Genotype, *Cythere latissima* NORMAN, 1865, Nat. Hist. Northumberland and Durham, Trans., vol. 1, p. 19, pl. 6, figs. 5–8.

Sars' (1925) description of the genus was considered paleontologically inadequate by Alexander (1933) who redescribed it on the basis of fossil specimens from the Cretaceous of Texas. Later, Alexander (1934) revised and condensed this description in his Midway paper. The Claiborne species show a few slight variations from the Midway generic description. The anterior and posterior teeth of the right valve have fewer cusps, three being the greatest number encountered. The line of concrescence, in some spe-

cies, deviates from the inner margin at the posterior as well as the anterior end. The muscle-scar pattern, in all cases noted, has but one scar in front of the vertical row of four scars. The Claiborne species differ from the Recent ones in being only about two thirds the size of the Recent species.

CYTHEROPTERON LISBONENSE

Martin, n. sp.

Plate 22, figures 1–3

Carapace minute, in side view elongate, subovate; dorsal margin strongly and evenly arched, ventral margin gently arched convexly; anterior end moderately broad, evenly arched; posterior end tapering, produced to form a short caudal process, curved slightly dorsally. Greatest length slightly ventral of center and greatest width slightly anterior of center. Carapace strongly convex, ala not greatly produced, forming a sharp ridge almost parallel to the ventral margin. Surface ornamentation consists of five ridges, posterior of center, curving postero-dorsally across carapace from ala, which are connected by short transverse ridges, with oblong depressions between them. Valves subequal, left only slightly larger than right. Viewed from the interior, the valves are moderately deep, flanked by a fairly broad marginal area. Line of concrescence coincides with inner margin except at anterior and posterior ends where the difference is about one third the width of the marginal area. Radial pore canals, occurring on both the anterior and posterior marginal areas, are few and widely spaced. The muscle-scar pattern consists of four oval scars in a vertical row, in front of which is a single oval scar. Hinge in right valve consists of a depressed crenulate area just below and parallel to the dorsal margin, flanked at both anterior and posterior ends by raised teeth bearing two or three cusps. In the left valve a corresponding crenulate bar occurs just below the dorsal margin, at either end of which is a depressed crenulate socket.

Dimensions of a right valve, syntype slide no. 2015, length, 0.42 mm, width, 0.24 mm. Dimensions of a complete carapace, syntype slide no. 2015, thickness, 0.24 mm.

Claiborne group, Eocene. Type locality, Loc. no. 2, Lisbon formation, Claiborne, Ala.

The surface ornamentation of *C. lisbonense* makes it very distinctive. Though widespread laterally, specimens of this species are not very common.

CYTHEROPTERON SPINOSUM

Martin, n. sp.

Plate 22, figures 4–6

Carapace minute, in side view elongate, ovate; dorsal margin strongly arched, greatest width anterior of middle; ventral margin arched convexly, obscured in central portion by ala; anterior end moderately broad, bluntly rounded; posterior end tapering, produced in a short caudal process, curved dorsally. Carapace strongly convex, ala strongly produced, tapering distally, and bluntly rounded. Upper surface of ala marked by furrows parallel to the posterior edge of the ala, which continue across the carapace halfway to the dorsal margin. Valves almost equal, left only slightly larger than right. Viewed from the interior the valves are fairly deep, flanked by a fairly broad marginal area especially on the anterior end. Line of concrescence coincides with inner margin, except on anterior and posterior ends where it departs slightly. Radial pore canals few and widely spaced. Hinge on right valve consists of a depressed crenulate area just below dorsal margin, flanked on both the anterior and posterior ends by a crenulate tooth with two or three cusps. The left valve hinge consists of a crenulate bar just below the dorsal margin, flanked both anteriorly and posteriorly by crenulate sockets into which fit the teeth of the right valve.

Dimensions of a right valve, syntype slide no. 2016, length, 0.44 mm, width, 0.30 mm. Dimensions of a complete carapace, paratype slide no. 2017, thickness, 0.36 mm.

Claiborne group, Eocene. Type locality, Loc. no. 28, Cook Mountain formation, Winn Parish, Louisiana.

Remarks.—*C. spinosum* resembles *C. aligerum* Alexander (1934) but lacks its surface markings and has heavier and wider ala, It also resembles *C. alatum* Sars (1926) but has a heavier and blunter ala. Also its surface marking are different. *C. alatum* is much larger than *C. spinosum*. *C. crassipi-*

natum Brady and Norman (1892) resembles *C. spinosum* but has less well developed ala. *C. spinosum* is common and fairly well distributed throughout the Clairborne localities.

Cytheropteron variosum

Martin, n. sp.

Plate 22, figures 7–9

Carapace minute, in side view elongate, ovate; dorsal margin strongly and evenly arched, ventral margin gently arched convexly; anterior end moderately broad, arched; posterior end bluntly pointed, produced into short caudal process. Greatest length ventral of center, greatest width slightly anterior of center. Carapace strongly convex, ala not greatly produced, but forming a rather sharp ridge almost parallel to and just over the ventral margin. Surface ornamentation varies. Some forms have fairly well pronounced elongate depressions running dorsally in rows from the ala almost to the dorsal margin. In some forms the depressions are not so well developed, and in others are entirely lacking, the surface being smooth. Valves subequal, left only slightly larger than right. Viewed from the interior, the valves are moderately deep flanked by a fairly broad marginal area. Inner margin coincides with line of concrescence except at anterior and posterior ends where the inner margin is slightly within the line of concrescence. Radial pore canals few and widely spaced. Hinge in right valve consists of a depressed crenulate area just below the dorsal margin, flanked at both anterior and posterior ends by a crenulate tooth bearing two or three cusps. In left valve, hinge consists of a crenulate bar just below the dorsal margin, flanked both anteriorly and posteriorly by crenulate sockets into which fit the crenulate teeth of the right valve.

Dimensions of a left valve, syntype slide no. 2018, length, 0.41 mm, width, 0.24 mm. Dimensions of a complete carapace, paratype slide no. 2020, thickness, 0.28 mm.

Claiborne group, Eocene. Type locality, Loc. no. 28, Cook Mountain formation, Winn Parish, Louisiana.

Remarks.—C. variosum resembles the genotype, *C. latissimum* (Norman, 1892), but differs in having less well developed ornamentation and ala, and in being decidedly smaller than *C. latissimum*. The smooth forms of *C. variosum* resemble *C. subcircinatum* Sars (1926) but are smaller and have a more well-developed ala. *C. variosum* also resembles *C. lisbonense* Martin but possesses decidedly different surface ornamentation. *C. variosum* is the most common Claiborne species, occurring in almost every locality.

Cytheropteron proboscense

Martin, n. sp.

Plate 22, figures 10–12

Carapace minute, in side view ovate; dorsal margin strongly arched; ventral margin gently arched convexly, obscured posterior of the center by the overhang of the ala; anterior end moderately broad, evenly arched; posterior end bluntly pointed. Greatest length slightly ventral of the center; greatest width slightly anterior of the center. Carapace strongly convex, ala produced to form a high curved ridge, recurved at the posterior end to form a

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Explanation of Plate 22

Figs. *1–3—Cytheropteron lisbonense* Martin, n. sp. ×100. Syntype slide no. 2015, interior and exterior views of right valve, and dorsal outline of complete carapace. (p. 177)

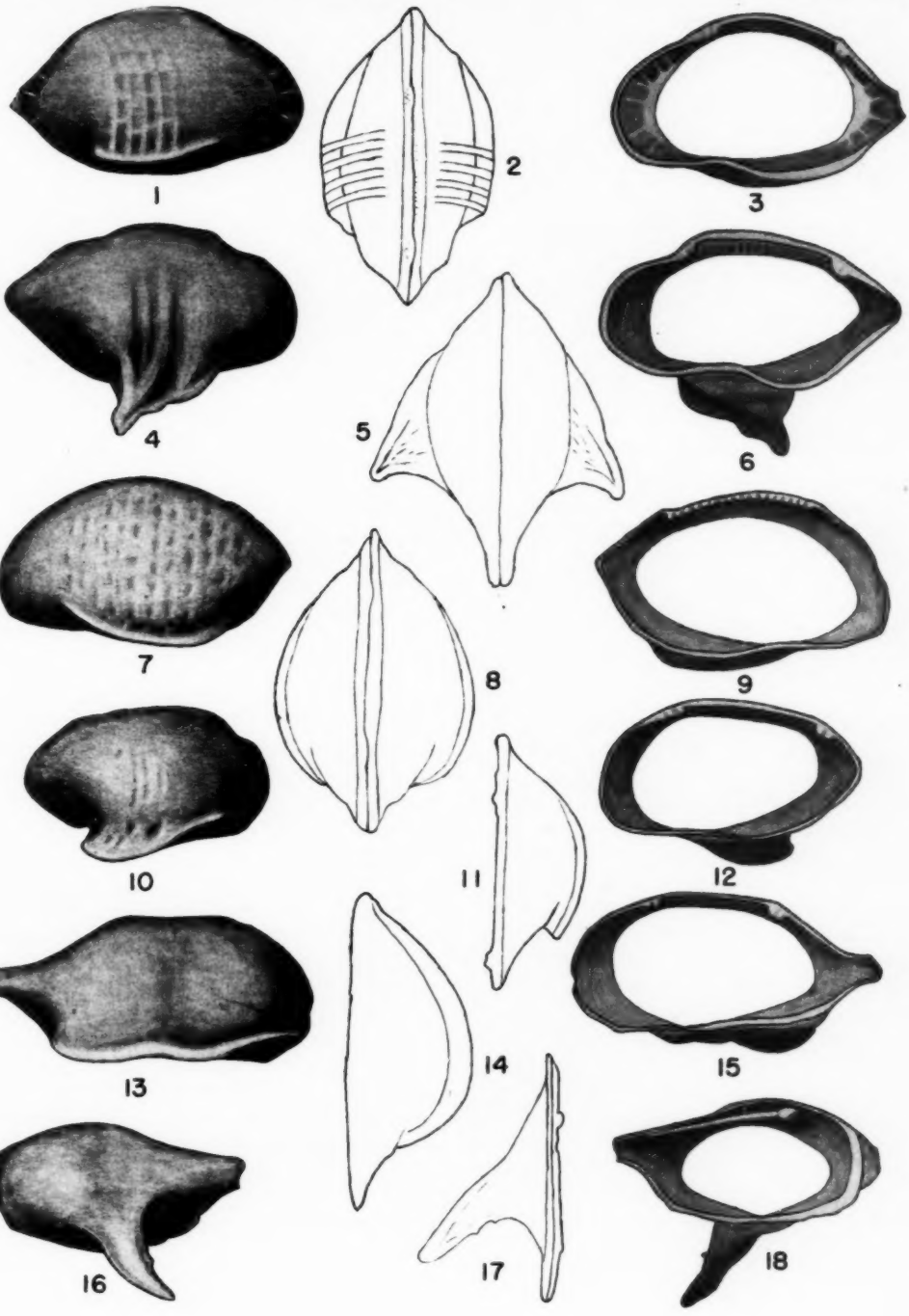
4–6—Cytheropteron spinosum Martin, n. sp. ×100, *4*, *6*, Syntype slide no. 2016, interior and exterior views of right valve. *5*, Paratype slide no. 2017, dorsal outline of complete carapace. (p. 177)

7–9—Cytheropteron variosum Martin, n. sp. ×100. *7*, *9*, Syntype slide no. 2018, exterior and interior views of left valve. *8*, Paratype slide no. 2020, dorsal outline of complete carapace. (p. 178)

10–12—Cytheropteron proboscense Martin, n. sp. ×100. Syntype slide no. 2021, exterior, interior, and dorsal views of right valve. (p. 178)

13–15—Cytheropteron incertum Martin, n. sp. ×100. Holotype slide no. 2022, exterior, interior and dorsal views of right valve. (p. 179)

16–18—Cytheropteron? fragillissimum Martin, n. sp. ×100. Holotype slide no. 2024, exterior, interior, and dorsal views of left valve. (p. 179)



Martin, Eocene Ostracoda

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beak. Surface ornamentation consists of two or three elongate grooves just dorsal of the ala; otherwise the surface is smooth. Viewed from the interior, the valves are moderately deep, flanked by a fairly broad marginal area. Line of concrescence coincides with inner margin except at anterior end where it departs slightly. Hinge in right valve consists of a depressed crenulate area just below the dorsal margin, flanked on both anterior and posterior ends by a raised crenulate tooth bearing two or three cusps. Hinge on left valve consists of a crenulate bar just below the dorsal margin, flanked on both anterior and posterior ends by depressed crenulate sockets into which fit crenulate teeth of the right valve.

Dimensions of a right valve, syntype slide no. 2021, length, 0.37 mm, width, 0.24 mm.

Claiborne group, Eocene. Type locality, Loc. no. 25, Cook Mountain formation, Winn Parish, Louisiana.

Remarks.—The shape of the ala makes *C. proboscense* distinctive. It is fairly rare in the Claiborne, being found in only four localities.

CYTHEROPTERON INCERTUM

Martin, n. sp.

Plate 22, figures 13–15

Carapace minute, in side view elongate, subovate; dorsal margin slightly arched; ventral margin almost straight, obscured for most of its length by the ala; anterior end broadly and evenly rounded; posterior end drawn out into an elongate caudal process curved slightly dorsally. Carapace convex with slight constriction just anterior of the middle. Ala developed into a sharp ridge, which is almost parallel to the ventral margin, overhanging it for a good distance; surface of carapace without other ornamentation. Valves subequal, left only slightly larger than right. Viewed from the interior, the valve is moderately deep, flanked by a fairly wide marginal area. Hinge in right valve consists of a depressed crenulate area just below the dorsal margin, flanked on both anterior and posterior ends by a single raised crenulate tooth bearing two or three cusps.

Dimensions of a right valve, holotype slide no. 2022, length, 0.45 mm, width, 0.21 mm. Dimensions of a complete carapace, hypotype slide no. 2023, thickness, 0.30 mm.

Claiborne group, Eocene. Type locality, Loc. no. 25, Cook Mountain formation, Winn Parish, Louisiana.

Remarks.—*C. incertum* resembles greatly *Cytherura wailesi* Howe and Law (1936) but possesses a definite *Cytheropteron* type of hinge. It is very rare in the Claiborne, being found in but two localities.

CYTHEROPTERON? FRAGILLISSIMUM

Martin, n. sp.

Plate 22, figures 16–18

Carapace minute, elongate, subovate, greatest width anterior of center; dorsal margin arched, tapering off at posterior; ventral margin arched convexly; anterior end rounded; posterior end tapering, produced in a caudal process. Carapace slightly convex; ala greatly produced, spinelike, fragile, arched slightly to the posterior, tapering to a point; no other surface ornamentation. Viewed from the interior the valve is shallow, flanked by a fairly broad marginal area. Line of concrescence coincides with inner margin except at anterior end, where they depart slightly. Hinge line on left valve consists of an anterior knob a slight distance below the dorsal margin; directly behind it is a bar whose distance from the dorsal margin decreases posteriorly until they are adjacent; a small depressed area occurs just under the dorsal margin at the posterior end of the bar.

Dimensions of a left valve, holotype slide no. 2024, length, 0.38 mm, width, 0.25 mm.

Claiborne group, Eocene. Type locality, Loc. no. 25, Cook Mountain formation, Winn Parish, Louisiana.

Remarks.— *C.? fragillissimum* probably represents a new genus, for its hinge line differs greatly from that of *Cytheropteron* and resembles no other genus yet described. *C.? fragillissimum* is common at the type locality but its fragility makes it almost impossible to obtain complete specimens. It is therefore inadvisable at present to attempt separation from *Cytheropteron*. It has been found only at the type locality.

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LOCALITIES

Loc. 1 (Henry V. Howe Loc. 203).—About 0.5 mile south of McBean Station, Ga., on south side of McBean Creek, 0.5 mile upstream from bridge. McBean formation.

Loc. 2.—E. A. Smith's Bed 14, Claiborne Bluff, Ala. Lisbon formation.

Loc. 3 (Henry V. Howe Loc. 84).—Bed 10 of Alabama Special Report 14, p. 271, 1926. 1 mile south of highway bridge, Claiborne Bluff, Ala. Gosport sand.

Loc. 4 (Henry V. Howe Loc. 175).—*Ostrea sellaeformis* bed, Coffeyville, Ala. Lisbon sand.

Loc. 5 (Marion Roberts Loc. 3).—On left bank Saline Bayou beneath L. and A. R.R. bridge, sec. 15, T. 9 N., R. 6 W. St. Maurice, Winn Parish, Louisiana. Sample beneath middle of fire iron ore ledges. Cook Mountain formation.

Loc. 6 (Marion Roberts Loc. 4).—On left bank Saline Bayou beneath L. and A. R.R. bridge, sec. 15, T. 9 N., R. 6 W., St. Maurice, Winn Parish, Louisiana. Sample beneath next to lowest of five iron ore ledges. Cook Mountain formation.

Loc. 7 (Henry V. Howe Loc. 258).—Road cut 2 miles SE of Minden, on road to Arcadia, Webster Parish, La. Cook Mountain formation.

Loc. 8 (J. B. Garrett Loc. 18).—Behind Speights at Columbus, Sabine Parish, La. Cook Mountain formation.

Loc. 9 (H. N. Fisk Loc. 267).—Ethridge No. 1 wildcat well near Colfax, Grant Parish, La., in NW corner sec. 19, T. 7 N., R. 3 W., cores at depth 2411–2452 ft. *Discocyclina advena* zone, Cane River formation.

Loc. 10 (Stadnichenko Loc. 2).—Evergreen Crossing of Elm Creek, 5 miles north of Giddings, Lee County, Tex. Cook Mountain formation.

Loc. 11.—1000 feet west of bridge at Smithville, Tex., 10 feet above low water level. Collector, R. R. Copeland, Jr. Weches formation.

Loc. 12 (Justin Rukas Loc. 274C).—4.9 miles north of Flora, 250 feet upstream from and west of bridge, Natchitoches Parish, La. Cook Mountain formation.

Loc. 13 (John Huner Loc. 20).—Road cut, east side Louisiana state highway 5, just north of Dodson, 0.1 miles north of line between secs. 22 and 27, T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 14 (John Huner Loc. 36).—Ditch up from creek on NW side of Louisiana state highway 6, $SW\frac{1}{4}NE\frac{1}{4}SE\frac{1}{4}NE\frac{1}{4}$, sec. 16, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 15 (John Huner Loc. 39).—In a field about $\frac{1}{4}$ mile south of Louisiana state highway 9, $SW\frac{1}{4}NE\frac{1}{4}NW\frac{1}{4}$, sec. 8, T. 11 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 16 (John Huner Loc. 46).—Ditch on north side Louisiana state highway 9, $NE\frac{1}{4}SE\frac{1}{4}SE\frac{1}{4}$, sec. 25, T. 12 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 17 (John Huner Loc. 50).—Ditch on west side Louisiana state highway 480, about 2 miles south of Calvin, in $NE\frac{1}{4}NW\frac{1}{4}NE\frac{1}{4}$, sec. 9, T. 11 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 18 (John Huner Loc. 55).—In ditch on south side Louisiana state highway 6, on gentle slope (15 feet below John Huner Loc. 54), $NW\frac{1}{4}NE\frac{1}{4}SE\frac{1}{4}$, sec. 3, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 19 (John Huner Loc. 59).—Along dim logging road SE from E. C. W. 23 in $SW\frac{1}{4}NE\frac{1}{4}SW\frac{1}{4}$, sec. 15, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 20 (John Huner Loc. 62).—In ditch on NE side E. C. W. road 21, in $SE\frac{1}{4}NE\frac{1}{4}NE\frac{1}{4}$, sec. 22, T. 10 N., R. 2 W., Winn Parish, La. Cook Mountain formation.

Loc. 21 (John Huner Loc. 82).—In ditch about 100 yards north of forestry building at C.C.C. camp on Louisiana state highway 480, in $NE\frac{1}{4}SE\frac{1}{4}NE\frac{1}{4}$, sec. 33, T. 11 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 22 (John Huner Loc. 94).—Along C.C.C. road from Louisiana state highway 6 to Cedar Bluff on Saline Bayou, in $SW\frac{1}{4}SE\frac{1}{4}SE\frac{1}{4}$, sec. 17, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 23 (John Huner Locs. 95b, 96).—Cut on SE

CHECK LIST OF CLAIBORNE SPECIES OF CYTHEROPTERON

Localities	*C. lisbonense*	*C. spinosum*	*C. variosum*	*C. proboscense*	*C. incertum*	*C.? fragillissimum*
1	—	—	x	—	—	—
2	x	—	—	—	—	—
3	—	—	x	—	—	—
4	x	—	—	—	—	—
5	—	—	x	—	—	—
6	—	—	x	—	—	—
7	—	—	—	—	x	—
8	—	x	x	—	—	—
9	x	—	—	—	—	—
10	x	—	x	—	—	—
11	x	—	—	—	—	—
12	—	—	—	x	—	—
13	—	x	x	—	—	—
14	—	—	x	—	—	—
15	—	x	x	—	—	—
16	—	—	x	—	—	—
17	—	—	x	—	—	—
18	—	x	—	—	—	—
19	—	—	x	—	—	—
20	—	x	x	—	—	—
21	—	x	—	—	—	—
22	—	—	x	—	—	—
23	—	x	x	—	—	—
24	—	x	x	—	—	—
25	—	x	x	x	x	x
26	—	x	x	—	—	—
27	—	—	x	—	—	—
28	—	x	x	x	—	—
29	—	—	x	—	—	—
30	—	x	—	—	—	—
31	—	—	x	—	—	—
32	—	—	x	—	—	—
33	—	—	x	x	—	—
34	—	x	x	—	—	—
35	—	x	x	—	—	—
36	—	x	—	—	—	—
37	—	—	x	—	—	—

side of Louisiana state highway 6, at intersection of road to St. Maurice in NW¼NW¼-SE¼NE¼, sec. 20, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 24 (John Huner Loc. 98).—Along C.C.C. tram line road about 2½ miles west of Calvin in creek branch, SE¼NE¼SE¼, sec. 7, T. 11 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 25 (John Huner Loc. 99).—Just below John Huner Loc. 98, in creek branch about 2½ miles west of Calvin, SE¼NW¼SE¼, sec. 7, T. 11 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 26 (John Huner Loc. 107).—In ditch on SE side E. C. W. road 109, about 2½ miles SW of Dodson, NW¼NW¼SW¼, sec. 5, T. 12 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 27 (John Huner Loc. 110).—In ditch on south side C.C.C. road in NE¼NW¼NW¼NE¼, sec. 7, T. 12 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 28 (John Huner Loc. 111).—Ditch leading to creek on south side of lower Dodson road (upper 2 feet of 12 foot bed), NE¼SW¼SW¼, sec. 28 T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 29 (John Huner Loc. 113).—Ditch leading to creek on south side of lower Dodson road (about 3 feet from base), NE¼SW¼SW¼, sec. 28, T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 30 (John Huner Loc. 116).—In ditch on west side of Louisiana state highway 1112, 0.1 miles south of Gansville, in SE corner, SE¼-SW¼, sec. 1, T. 13 N., R. 4 W., Winn Parish, La. Cook Mountain formation.

Loc. 31 (John Huner Loc. 117).—In ditch on north side of Louisiana state highway 547, 0.16 miles north and east of Gansville, Jackson Parish, La. Cook Mountain formation.

Loc. 32 (John Huner Loc. 212).—From drill hole, depth 17 ft. 6 in., 10 ft. west of Louisiana state highway 5 in SE corner NW¼NW¼SE¼, sec. 5,

T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 33 (John Huner Loc. 213).—From type Milams outcrop at base of scarp on SW side of Antoine Creek (6 in. below zone of limestone concretions), SW¼NE¼, sec. 17, T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 34 (John Huner Loc. 215).—From type Milams outcrop on scarp on SW side of Antoine Creek (about 4 ft. above John Huner Loc. 214), SW¼NE¼, sec. 17, T. 13 N., R. 3 W., Winn Parish, La. Cook Mountain formation.

Loc. 35 (John Huner Loc. 224).—Base of slope in ditch on north side of Couley road, in SW corner SW¼NW¼, sec. 2, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 36 (John Huner Loc. 226).—About 4 feet above the top of marl in ditch on south side of Couley road, in NW corner, NE¼NW¼SW¼, sec. 2, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

Loc. 37 (John Huner Loc. 233).—In creek gulley on south side of Louisiana state highway 6, in NE corner NW¼NE¼SW¼, sec. 20, T. 10 N., R. 5 W., Winn Parish, La. Cook Mountain formation.

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LARGE FORAMINIFERA FROM GUAM

W. STORRS COLE

ABSTRACT—Limestones from eight localities on the island of Guam have yielded recognizable Foraminifera. The important species for age determination are *Spiroclypeus higginsi* Cole, n. sp., *Miogypsinoides dehaartii* van der Vlerk var. *formosensis* Yabe and Hanzawa and *Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth. The age is lowermost Miocene, Tertiary *e* of the Netherland Indies scale. At least two distinct horizons are present.

AS FAR as I have been able to ascertain, the large Foraminifera described in this article are the first to be reported from the island of Guam, located in the Pacific Ocean between longitude 144°36′ and 144°58′ East and between latitude 13°14′ and 13°40′ North. The samples were collected by Capt. Spencer L. Higgins of the Medical Corp of the U. S. Navy.

The following localities are quoted from notes furnished by Captain Higgins. Figure 1 shows the approximate location of the stations.

LOCALITIES

Map Number	*Field Number*	*Description*
2	C-23	Natural bridge, central valley, east of Agat.
7	C-27	From a conical hill 2 miles east of Fena, and southeast of the Disappearing River, from the western aspect, alongside trail to the top, elevation 100 feet.
8	C-29	A "cascao" pit, about one mile north of Agat, along the highway near the "Agat Y," elevation 25 feet.
1	C-44	Near C-57, elevation 10 feet.
1	C-57	Santa Catalina Point, on shore east of Mt. Santa Rosa.
4	C-64	Disappearing River cavern, elevation 30 meters.
6	D-3	Two hundred feet below the top of Mt. Fina Santos (north and east of Merizo), on the southwestern side, at an elevation of 550 feet.
5	D-6	East wall of Geus River canyon above Merizo dam, limestone, striking N 45°W, dipping 15°NE., at an elevation of 100 feet .
5	D-7	Same location as D-6.
10	D-9	From the top of the western escarpment of Mt. Chao, 200 feet west of Mt. Tenjo road, strike N. 22½° E., dip 30° SE. Strata are composed of alternating laminae of limestone and tuff 2 to 3 inches in thickness.
3	D-10	Bottom of gorge at top of Maulat Falls on the Maulat branch of the Talofofo River, elevation 245 feet.
3	D-11	A boulder at the bottom of Maulat Falls on the Maulat branch of the Talofofo River, elevation 198 feet.
2	D-12	Natural bridge, central valley of the Talofofo River, east of Agat, at stream level, elevation 200 feet.
9	D-14	Yona well, depth 170 feet, elevation of surface 250 feet.

The stations which yielded the most satisfactory material for specific determination are C-27, D-7 and D-12. The material from D-7 is almost entirely composed of the tests of Foraminifera. Thin sections of this material show that the dominant specimens are a small species of *Lepidocyclina* which has been identified as *L.* (*Nephrolepidina*) *parva* Oppenoorth. Associated with this there are a few oblique horizontal sections of a species of *Cycloclypeus*. Although these sections are not oriented correctly for detailed study, the internal features which may be observed suggest that this species belongs to *C. eidae* Tan. In addition, there are a few sections of a small *Spiroclypeus*, which are not numerous enough for specific determination. This association indicates that the rocks from this station should be referred to lowermost Miocene, Tertiary *e* stage of the Netherland Indies time scale. The sample from C-27 contains *L. parva* in considerable numbers.

The thin sections from D-12 contain abundant specimens representing two genera, of which *Spiroclypeus higginsi* Cole, n. sp., is more abundant than *Miogypsinoides dehaarti* van der Vlerk var. *formosensis*

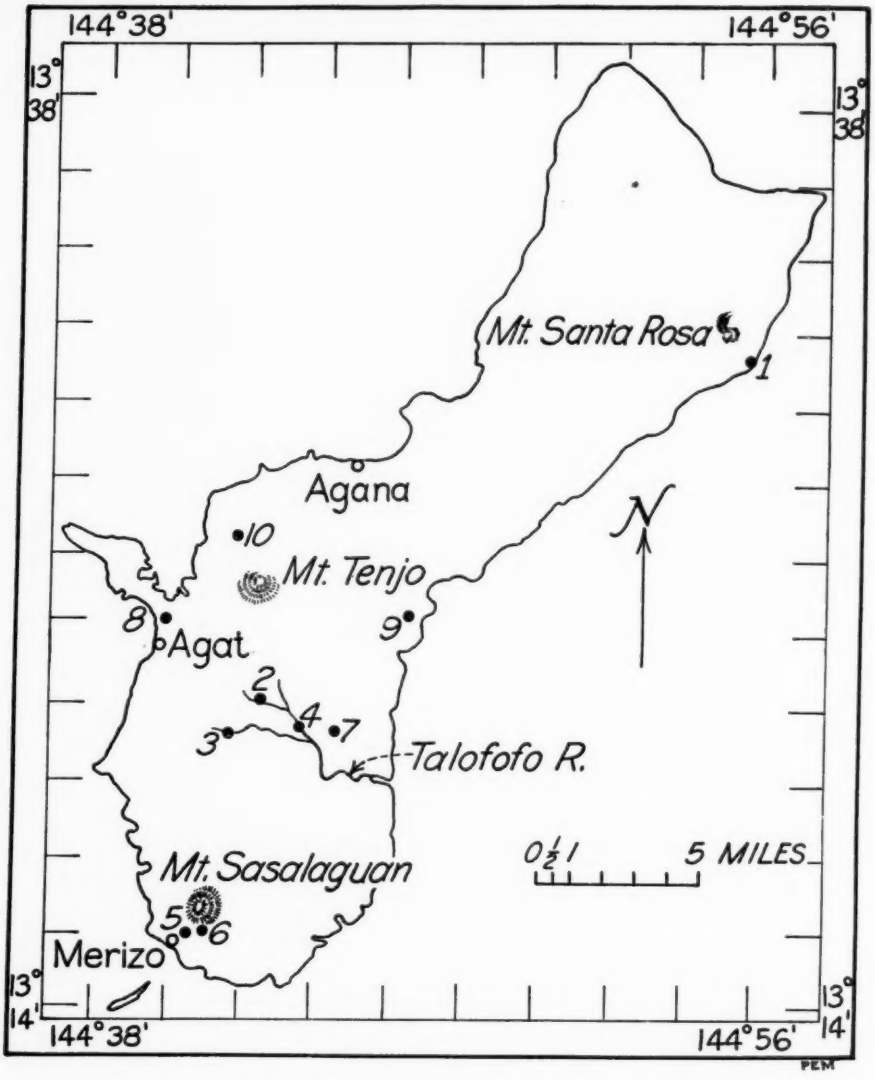


FIG. 1.—Sketch map of Guam, showing location of samples.

EXPLANATION OF PLATE 23

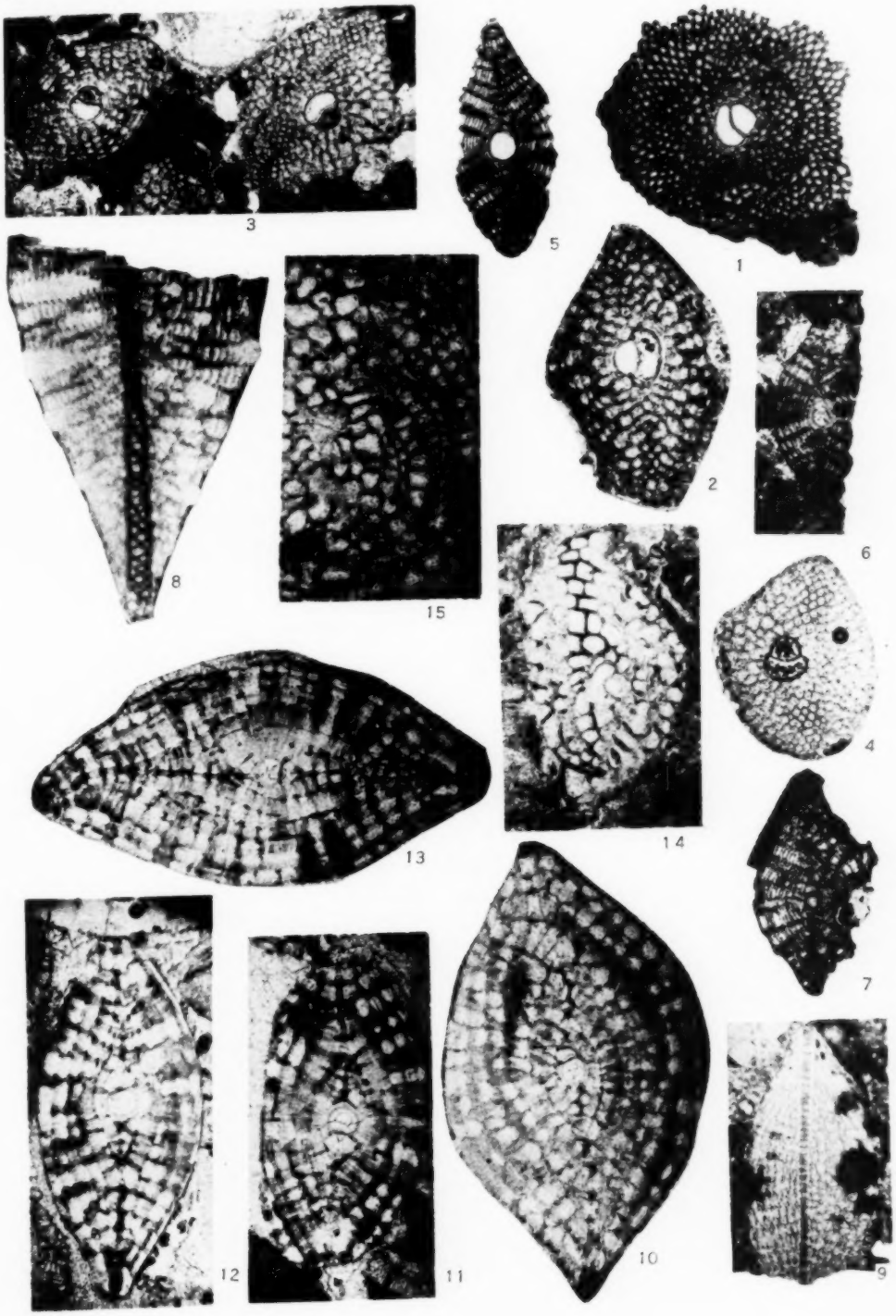
(All figures, ×26)

FIGS. *1–7*—*Lepidocyclina* (*Nephrolepidina*) *parva* Oppenoorth. *1*, Equatorial section; *2–4*, oblique equatorial sections; *5–7*, vertical sections. Locality D-7. (p. 188)

8—*Lepidocyclina* sp. Locality D-3. (p. 188)

9—*Lepidocyclina* sp. Locality D-11. (p. 188)

10–15—*Spiroclypeus higginsi* Cole, n. sp. *10–13*, Vertical sections; *14*, oblique equatorial section showing embryonic apparatus and equatorial chamberlets; *15*, oblique equatorial section showing equatorial chamberlets. *11–13*, *15*, Syntypes, Locality D-12; *10*, *14*, Locality D–10. (p. 185)



Cole, Tertiary Foraminifera

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Yabe and Hanzawa. These specimens are embedded in a limestone matrix with rather numerous calcareous algae. The age of the material from this station is lowermost Miocene, Tertiary *e*.

The thin sections from D-10 contain a few specimens of *Spiroclypeus* which are identical in every respect to *S. higginsi* found in the material from D-12. In addition, there is one vertical section of a specimen of *Lepidocyclina* sp. Station D-10 may be safely assigned to the same age as D-12, lowermost Miocene, Tertiary *e*.

D-11 contains a few specimens of *S. higginsi* besides one vertical section of *Lepidocyclina* sp., which is different from that reported from D-10. In addition there is one section which suggests *Neoalveolina pygmaea* (Hanzawa). This station is lowermost Miocene, Tertiary *e* in age.

One vertical section of a *Lepidocyclina* sp. was found in the thin section from D-3. Abundant calcareous algae and a few sections of small foraminifera comprise the remainder of these thin sections. The general appearance suggests lowermost Miocene, but this cannot be stated with certainty.

Thin sections from station C-64 show pebbles containing *Spiroclypeus higginsi* surrounded by a limestone matrix containing numerous specimens of *Rotalia schroeteriana* Parker and Jones, besides one specimen of *Cycloclypeus* sp. and rather abundant calcareous algae. The inclusion of pebbles with *S. higginsi* indicates that the rocks at this station are younger than those from the other locatities at which *S. higginsi* occurs.

The thin sections from C-23 contain abundant *Rotalia schroeteriana* besides one specimen of *L. parva*. The age of the rocks at C-64 and C-23 is lowermost Miocene, Tertiary *e*, but a younger horizon than that of the *Spiroclypeus*-bearing stations.

Thin sections from C-29, C-44, D-6, D-9, D-14 and C-57 did not contain recognizable larger Foraminifera. Therefore, the age of the rocks at these stations cannot be given.

OCCURRENCE OF TERTIARY LIMESTONES ON OTHER PACIFIC ISLANDS

As more extensive collections are made from the islands of the Pacific, it becomes apparent that many of them contain foraminiferal limestones of Early and Middle Tertiary age.

Small limestone fragments containing *Lepidocyclina* have been found intermingled with the coral conglomerate of recent origin which forms the surface material of the largest islet (Jabor) of the atoll Jaluit, of the Marshall Group (Yabe and Aoki, 1922).

Hanzawa (1925) has reported the occurrence of large Foraminifera on various of the islets of the Bonin Group. On Peer Island (Chichi-jima) he found a white, compact, stratified limestone with abundant *Lepidocyclina* (*Eulepidina*), *Heterostegina*, and *Spiroclypeus*. This limestone is approximately the same in age as the rocks of Guam.

Whipple (1932) has reported the occurrence of Eocene limestones above the volcanic base of Eua, Tonga Archipelago, containing abundant large Foraminifera.

From Vitilevu, the chief island of Fiji, Whipple (1934) described a number of large Foraminifera and referred the rocks containing these to stage *e* of the Miocene. Recently, I have had opportunity to study a large collection from the Lau Group of islands, of Fiji. These samples contained abundant large Foraminifera referred to stage *f* of the Miocene. The report of this study is to be published in the near future by the Bishop Museum at Honolulu.

Acknowledgments.—My indebtedness to Captain Higgins is expressed for furnishing the samples and notes, and in addition, for payment of work in making the thin sections. Dr. T. Wayland Vaughan kindly read the manuscript, offered valuable suggestions, and checked several references which were not available to me. The thin sections which were actually used in the preparation of this article will be donated to the U. S. National Museum by Captain Higgins.

Family CAMERINIDAE Meek and Hayden, 1865

Subfamily CAMERININAE Cushman, 1928

Genus SPIROCLYPEUS H. Douvillé, 1905

SPIROCLYPEUS HIGGINSI Cole, n. sp.

Plate 23, figures 10–15
Plate 24, figure 13

Test small, normally evenly lenticular, but a few individuals show a slight flange. The smallest individual measured had a

thickness of 0.93 mm and a diameter of 1.9 mm; the largest, a thickness of 1.27 mm and a diameter of 2.63 mm. The most perfectly developed flange had a width of 0.5 mm and a thickness of 0.3 mm.

Only oblique median sections were obtained, and these show the chambers divided into chamberlets, which near the periphery of the test have an internal radial diameter of 100 μ and a transverse diameter of 60 μ. Transverse sections show that the equatorial layer is very thin, with an average internal height of 20 μ. The equatorial layer is virtually the same thickness from the center of the test to the periphery.

Transverse sections show that the embryonic apparatus consists of two subequal chambers, the initial chamber has a height of about 140 μ and a length of 120 μ; the second chamber has a height of about 80 μ and a length of about 60 μ.

The lateral chambers are very thin and compressed between thick roofs and floors. There are 7 or 8 lateral chambers to a tier on each side of the embryonic apparatus. They decrease regularly in number toward the periphery until there is only a single layer at the periphery. Lateral chambers may have a length of as much as 180 μ, but the height internally is never more than 10 μ. The roofs and floors have an average thickness of 80 μ. Pillars are numerous and rather regularly spaced. Those at the center of the test have an external diameter of about 140 μ. They taper slightly toward the center of the test. The lateral chambers are in tiers rather regularly arranged between the pillars.

Geologic horizon and localities.—Lowermost Miocene, Tertiary *e*, from localities D-12, D-10 and D-11.

Remarks.—This species resembles *S. leupoldi* van der Vlerk in size and shape, but vertical sections demonstrate that there are a number of differences. The lateral chambers of *S. leupoldi* are arranged in very regular tiers with 10 to 12 chambers to the tier on either side of the median plane. The floors and roofs of the lateral chambers are thin, and pillars are lacking. *S. higginsi* has lateral chambers with very thick roofs and floors, rather well developed pillars and a maximum of 8 chambers on either side of the median plane.

Yabe and Hanzawa (1927–1929) illustrated specimens from Mortalbar, Rizal, Island of Luzon, Philippines, which seem to be identical with *S. higginsi*, even though they considered that their specimens represented *S. margaritatus* (Schlumberger). *S. margaritatus* is a much larger form with a well developed, thin flange.

This species is named in honor of Capt. Spencer L. Higgins.

Genus CYCLOCLYPEUS W. B. Carpenter, 1856

Subgenus CYCLOCLYPEUS W. B. Carpenter, 1856

CYCLOCLYPEUS sp. cf. C. EIDAE Tan

Plate 24, figure 9

Cycloclypeus eidae TAN, *1932*, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indié, no. 19, pp. 50–59, pl. 5, fig. 6; pl. 12, figs. 2–3; pl. 13, figs. 1, 2, 4–6 (references and synonomy).

Several oblique horizontal sections of a small specimen of *Cycloclypeus* were found. Although these were not sufficient for exact determination, the features suggest that these specimens are close to *C. eidae*. One specimen is figured.

Geologic horizon and locality.—Lowermost Miocene, Tertiary *e* from locality D-7.

Subfamily MIOGYPSININAE Vaughan, 1928

This subfamily has been transferred recently from the family Orbitoididae to the

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EXPLANATION OF PLATE 24
(All figures, ×26)

FIGS. *1–7*—*Miogypsinoides dehaartii* Van der Vlerk var. *formosensis* Yabe and Hanzawa. *1–3*, *7*, Vertical sections; *4–6*, equatorial sections. *1–5*, Locality D-12; *6–7*, Sekihekiryô, Taihoku Prefecture, Formosa. (p. 187)

8—*Neoalveolina pygmaea* (Hanzawa). Locality D-11. (p. 187)

9—*Cycloclypeus* sp. cf. *C. eidae* Tan. Slightly oblique equatorial section. Locality D-7. (p. 186)

10–12—*Rotalia schroeteriana* Parker and Jones. *10*, Transverse section; *11*, *12*, equatorial sections. Locality C-64. (p. 187)

13—*Spirocylpeus higginsi* Cole, n. sp. Vertical section. Locality D-11. (p. 185)

10

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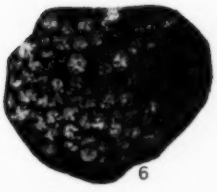
8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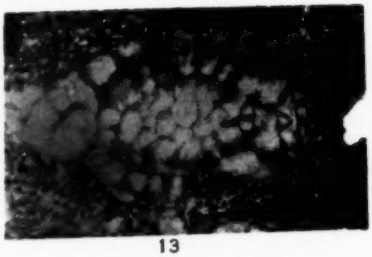
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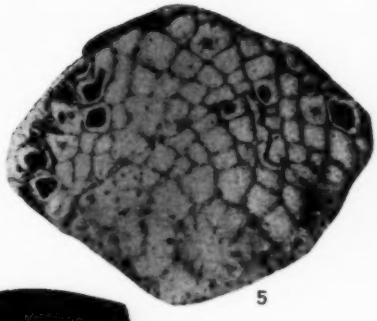
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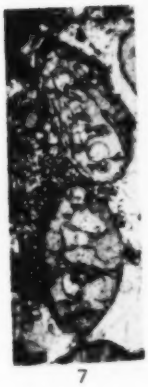
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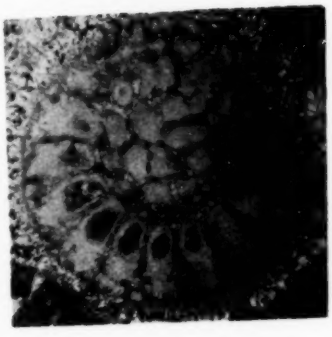
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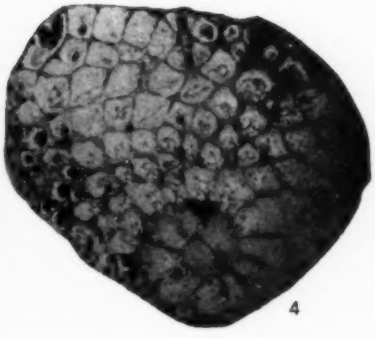
4

Cole, Tertiary Foraminifera

UNIV OF MICH.

Rotaliidae by Barker and Grimsdale (1937). I disagree with this view (Cole, 1938) and believe that the subfamily should be transferred to the family Camerinidae.

Genus MIOGYPSINOIDES Yabe and Hanzawa, 1928

Doctor Vaughan (personal communication) states that in his opinion *Miogypsinoides* represents a valid genus rather than a subgenus of *Miogypsina*.

MIOGYPSINOIDES DEHAARTII van der Vlerk var. FORMOSENSIS Yabe and Hanzawa

Plate 24, figures 1–7

Miogypsina (*Miogypsinoides*) *dehaartii* van der Vlerk var. *formosensis* YABE AND HANZAWA, *1928*, Imp. Acad. Japan, Proc., vol. 4, no. 9, p. 534, text figs. 1a–b; *1930*, Tôhoku Imp. Univ., Sci. Reports, 2nd ser. (Geology) vol. 14, no. 1, pp. 32–33, pl. 3, figs. 4, 5, pl. 4, figs. 3, 4, pl. 7, fig. 12, pl. 9, fig. 9, pl. 11, figs. 1–6, 12.

Test small, ovate in plan, compressed, irregularly lenticular to wedge-shaped in cross-section, normally with the greatest thickness through the initial portion of the test from which point the test tapers slightly toward the distal edge. The thickness varies from 0.68 to 0.85 mm, the diameter varies from 1.5 to 2.7 mm. No microspheric individuals were observed.

The embryonic apparatus is situated apically and consists of two equal or subequal chambers, surrounded by a coil of 10 to 12 more or less rectangular chambers which are larger than the succeeding equatorial chambers. The initial chamber has a diameter of about 160 μ. The distance across the embryonic apparatus measured parallel to the length of the test is about 0.8 mm.

Equatorial sections show that the median layer is composed of rhomboidal chambers, which increase in size from the embryonic apparatus to the distal edge of the test. The largest chambers have a radial diameter of about 200 μ and a transverse diameter of 240 μ.

Transverse sections show that the equatorial chambers have a height of about 120 μ, bordered on each side by the thick walls of the test without lateral chambers.

Geologic horizon and locality.—Lowermost Miocene, Tertiary *e*, from locality D-12.

Remarks.—Yabe and Hanzawa separate the variety *formosensis* from typical *dehaartii* on the position of the chambers of the embryonic apparatus. In typical *M. dehaartii* the apical portion of the test is occupied by the second chamber, but in the variety *formosensis* the eighth chamber of the coil occupies this position. The specimens from Guam have the seventh or eighth chamber of the coil in the apical position.

Figures 6, 7, plate 24 are photomicrographs of specimens from Sekihekiryô in Taihoku Prefecture, Formosa, introduced for comparison. The thin section containing these specimens was presented to me by Dr. T. Wayland Vaughan and was made from material presented to Dr. Vaughan by Professor Yabe. Except for size, the Guam specimens exhibit identical structures and arrangement when compared with the specimens from Formosa.

Family ALVEOLINELLIDAE Cushman, 1928

Genus NEOALVEOLINA Silvestri, 1928

NEOALVEOLINA PYGMAEA (Hanzawa)

Plate 24, figure 8

Fasciolites pygmaea HANZAWA, *1930*, Tôhoku Imp. Univ., Sci. Reports, 2d ser. (Geology), vol. 14, no. 1, p. 94, pl. 26, figs. 14–15.

Neoalveolina pygmaea BAKX, *1932*, Geol. Mijnbouwk. Gen. v. Ned. en Kol., Verh., geol. serie, dl. 9, pp. 237–39, pl. 3, figs. 18–20 (references and synonomy).

One section that is doubtfully referred to this species is figured.

Geologic horizon and locality.—Lowermost Miocene, Tertiary *e*, from locality D-11.

Family ROTALIIDAE Reuss, 1860

Subfamily ROTALIINAE Schultze, 1854

Genus ROTALIA Lamarck, 1804

ROTALIA SCHROETERIANA Parker and Jones

Plate 24, figures 10–12

Rotalia schroeteriana (Parker and Jones, ms.), CARPENTER, *1862*, Introd. Foram., p. 213, pl. 13, figs. 7–9.—HANZAWA, *1931*, Tôhoku Imp. Univ., Sci. Reports, 2d ser. (Geology), vol. 12, no. 2A, p. 157, pl. 26, figs. 6–8 (references).

These sections are very similar to those figured by Hanzawa.

Geologic horizon and localities.—Lower-

most Miocene, Tertiary *e*, from localities C-23 and C-64.

Family ORBITOIDIDAE Schubert, 1920

Subfamily ORBITOIDINAE Prever, 1904

Genus LEPIDOCYCLINA Gümbel, 1870

Subgenus NEPHROLEPIDINA H. Douvillé, 1911

LEPIDOCYCLINA (NEPHROLEPIDINA) PARVA Oppenoorth

Plate 23, figures 1–7

Lepidocyclina parva OPPENOORTH, *1918*, Geol. Mijnbouwk. Gen. v. Ned. en Kol., Verh., geol. serie, dl. 2, p. 255, pl. 8, figs. 11–12; pl. 9, fig. 9. VAN DER VLERK, *1928*, Wetensch. Meded. v. d. Dienst v. d. Mijnbouw in Ned.-Indié, no. 8, p. 28, figs. 24a–b; *1929*, ibid, no. 9, p. 24, figs. 22, 47a–b.

Test small, lenticular, surface ornamented by a fine reticulate mesh without papillae. The test of most specimens slopes regularly from the inflated central portion to the periphery, but a few specimens have the suggestion of a very narrow keel. The outline of the test is faintly polygonal. The diameter of megalospheric individuals varies from 1.1 to 1.7 mm; the thickness from 0.56 to 0.68 mm. No microspheric specimens were observed.

The embryonic apparatus is nephrolepidine in type, composed of a large initial chamber partially embracing the second chamber. The internal diameter of the embryonic apparatus measured across both chambers varies from 220 to 240 μ. The initial chamber has internal diameters of about 100×200 μ; the second chamber has internal diameters of about 120×150 μ. The height of the embryonic chambers is about 150 μ. The wall of the embryonic apparatus is thin.

Median sections show the equatorial chambers to be rhomboid in shape with a radial diameter of about 60 μ and a transverse diameter of about 40 μ. There is very little difference in size between the equatorial chambers at the center of the test and those at the periphery. Transverse sections show that the equatorial layer is very thin and approximately of the same thickness from the center of the test to the periphery. The internal height of the equatorial chambers is about 30 μ.

The lateral chambers occur in regular tiers with 7 or 8 chambers to a tier at the center of the test. The number of chambers to a tier decreases regularly as the periphery is approached so that at the periphery of the test there is only a single layer of lateral chambers. The length of lateral chambers at the periphery of the test directly over the embryonic apparatus varies from 80 to 100 μ; the height of these lateral chambers is about 30 to 40 μ. The roofs and floors of these lateral chambers have a thickness of about 20 μ.

Small pillars are normally present. Certain transverse sections are apparently devoid of pillars, others have only one pillar, and other thin sections show a number of pillars spaced between the tiers of lateral chambers. The largest pillar measured had a surface diameter of 45 μ, but most of the pillars have a smaller diameter. The pillars have parallel sides for about half their length inward from the periphery after which they taper rapidly.

Geologic horizon and localities.—Lowermost Miocene, Tertiary *e*, from localities D-7, C-23 and C-27.

Remarks.—Van der Vlerk (1928) states that this species is confined to Tertiary *e*. Umbgrove (1931) gives its stratigraphic range as Tertiary *e* and *f*. Caudri (1934), writing of the age of rocks in Soemba containing this species, states that "*L. parva*, here as on N. E. Borneo, is found in Tertiary *f*."

It appears from this that *L. parva* may be found in either Tertiary *e* or *f*, but the general association of this species in Guam suggests that the age of the station under discussion is Tertiary *e* rather than *f*. This conclusion is strengthened by finding *Spiroclypeus* sp. here, and a species of *Cycloclypeus* of the *eidae* type.

LEPIDOCYCLINA sp.

Plate 23, figure 9

This species is represented in the present collection by only one accidental vertical section. The details are not sufficient for specific identification.

Locality.—Station D-11.

LEPIDOCYCLINA sp.

Plate 23, figure 8

This species is represented by a portion of an oblique section.

Locality.—Station D-3.

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W. STORRS COLE, OHIO STATE UNIVERSITY, COLUMBUS, OHIO. MANUSCRIPT RECEIVED BY THE EDITOR, DECEMBER 9, 1938.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 190–202, 75 TEXT FIGS., MARCH, 1939

DEVONIAN AND SILURIAN FORAMINIFERA FROM OKLAHOMA

HUBERT A. IRELAND

ABSTRACT.—Silurian and Devonian arenaceous Foraminifera found during a study of insoluble residues from 6,300 well and outcrop samples from the Arbuckle Mountains and central Oklahoma are here reported. The forms found are from the members of the Hunton formation. The descriptions include one new genus, twenty-one new species, and three new varieties from the Silurian; and one new genus, six new species from the Devonian. Twenty-six other species were identified and listed of of which seventeen are illustrated.

STUDY OF insoluble residues from strata of pre-Mississippian age in the Arbuckle Mountains and the Oklahoma portion of the Ozark Plateau and correlation of those strata by residues from well samples taken from the area lying between the surface exposures is here reported. Arenaceous Foraminifera, being insoluble in the hydrochloric acid used for making residues, appeared as an important constituent of the dissolved samples. An examination of the well cuttings or rock specimens does not reveal the fossil forms until they are concentrated by the solution of the matrix in which they were embedded. Arenaceous Foraminifera are abundant in the Hunton formation but were not found in any other pre-Mississippian strata. The purpose of this paper is to describe the fauna found. Correlations indicated by use of the residues and the Foraminifera has been published (Ireland, 1936).

Surface outcrops of the Hunton formation were sampled, zones with fossils being thus defined for use in correlation. The Hunton formation is divided into five members in the Arbuckle Mountains—Chimney Hill limestone (Alexandrian), Henryhouse shale (Niagaran), Haragan limestone (Helderberg), Bois d'Arc limestone (early Oriskany), and Frisco limestone (late Oriskany). Only the lower four of these are recognized in the subsurface section; the Frisco limestone is generally absent and the lower formations are greatly eroded north and northeast of the Arbuckle Mountains, in some places being entirely absent (McClellan, 1930, p. 1543). Only the Chimney Hill, Henryhouse, and Haragan beds contain Foraminifera. The Henryhouse and Haragan are separated by a disconformity, but due to lithologic similarity they are difficult to separate at the outcrop and are not commonly differentiated in the subsurface section. The insoluble residues are the same in both members, but by the aid of arenaceous Foraminifera, where present, it is possible to differentiate each unit. Difference between species of the Henryhouse and Chimney Hill members is not sufficient to distinguish them, though the Foraminifera are much more abundant and more diverse in the Chimney Hill. Moreman (1933) has also noted the absence of index forms for the Henryhouse. The insoluble residues are quite distinctive in both the Henryhouse and Chimney Hill, and with the Foraminifera it is readily possible to distinguish them, except in northeastern Oklahoma where the two members are represented by the St. Clair limestone.

The St. Clair limestone near Marble City, Okla., has a very small fauna, in size as well as in numbers. The tests of the Foraminifera are composed of such fine sand that the exteriors appear hyaline, and they have a much larger amount of cement than similar species a hundred miles to the southwest. The species found in the St. Clair show that the lower part is equivalent to the Chimney Hill limestone of the Arbuckle Mountains and the Brassfield limestone of Missouri. The upper part of the St. Clair is known to be Silurian but no Foraminifera were found in it. The St. Clair is at least 170 feet thick at the outcrop and is generally encountered in wells in southern Okmulgee and Muskogee counties, Oklahoma.

The few Devonian forms described here were found in the Haragan beds. Descriptions of Devonian arenaceous Foraminifera are not many (Miller and Carmer, 1933). The Foraminifera found by me in Mississippian rocks of Oklahoma indicate that the arenaceous forms were abundant after Devonian times, and the Silurian fauna shows abundant forms before the Devonian, but for some reason the Devonian arenaceous forms are uncommon. The presence of Silurian forms in the upper portion of thick Hunton sections is taken as evidence that the Devonian portion is thin. The beds are thin, due to northeastward overlap as well as because of erosion.

Well samples containing arenaceous Foraminifera occur in a strip two or three townships wide extending northwest from the Arbuckle Mountains near Ada, Okla. Foraminifera are rare or absent northeast of the strip, due to complete erosion of the Hunton around the "Seminole Inlier," and to erosion of all but the basal part of the Chimney Hill, which has a few forms. Another factor may be that less favorable conditions for preservation existed outside of this area. The specimens diminish in size and in development northward from the Arbuckle area. Some of the species are emaciated, delicate, and show minor individual anomalies. These characteristics may be attributed to greater distance from neritic conditions, signifying less favorable environment where the sand grains available for tests were finer than those near shore. It is possible that the forms having the small tests belong to different species, but the remarkable resemblance to the type forms suggests that they are varieties rather than distinct species. The forms in the Arbuckle area are large, well developed, and with thick-walled tests that indicate a favorable environment. The contrasts in development may be illustrated by the three most common forms, *Ammodiscus exsertus* Cushman, *Ammodiscus incertus* D'Orbigny, and *Bathysiphon curvus* Moreman.

Moreman (1930) has done the pioneer work on Silurian arenaceous Foraminifera. Most of the forms described by him are found in the residues of well samples from central Oklahoma, and a number are among those described by Dunn (1932) from the central Mississippi valley east of the Ozarks. The present addition gives a definite Silurian fauna which can be correlated across the central part of the United States.[1]

THE FORAMINIFERAL FAUNAS

All species of *Bathysiphon*, *Psammosphaera cava* Moreman, *Ammodiscus exsertus* Cushman, *Ammodiscus incertus* d'Orbigny, and *Lituotuba exserta* Moreman are forms which are present in large numbers in nearly all surface and subsurface sections containing Silurian beds. The species of *Bathysiphon* extend into the Devonian and cannot be used as index fossils. *Psammosphaera cava* Moreman shows a great variation in size, ranging from 0.38 to 0.68 mm in diameter. It is confined to the Silurian. *Psammosphaera excerpta* Dunn is very abundant and occurs in both the Silurian and the Devonian. *Lagenammina distorta* Ireland, n. sp., resembles *L. sphaerica* Moreman in general form, but the test, and especially the neck, is so frequently distorted when associated forms are not distorted that it is considered a new species.

The genus *Bifurcammina* represents a new and unusual group. Specimens resembling these forms have been described by Moreman as questionably a form of *Ammodiscus*. The last whorl of the test is always bifurcated, terminating with a double aperture in various manners. All of the species except *B. bifurca* Ireland, n. sp., were found in the section at Dougherty, Okla.

The samples from Tulip Creek and Lick Creek in the Arbuckle Mountains show an unusually abundant fauna composed chiefly of *Thurammina*, with a noticeable lack of Ammodiscinidae. In contrast to this, the samples from Dougherty have many more Ammodiscinidae than *Thurammina*.

Although Devonian forms are not common, the ones described are specimens that are distinctly different, appear to be with-

[1] Within the last few weeks I have examined insoluble residues prepared from the Silurian limestone of Ohio and Indiana by R. R. Priddy of Ohio State. The material contains quite a number of arenaceous Foraminifera which have been recognized elsewhere in the Mississippi valley and in material which I have studied. Descriptions of the species are not expected to be published, but the occurrence is worthy of note.

out anomalies, and show very definite family and generic characteristics. One of the best Devonian index forms is *Psammophax bipartita* Ireland, n. sp. It occurs commonly near Franks, Okla., and often is much more wedge-shaped than the figured type. Many of the specimens apparently were attached in crevices or other constricted places.

Most of the new species are based on an abundance of specimens, but some that are described from just a few forms are so indicated in the descriptions. In cases where only a few forms were used, new species have been named only where distinctions were so outstanding that specific differences were clearly indicated. The fact that the Foraminifera described are very primitive forms and that many of them are confined to beds with a short vertical range is not favorable to great diversification. Consequently, microspheric and megalospheric forms were not expected or found among many species.

Index Foraminifera of the Silurian and Devonian, as indicated by my studies, are listed below.

INDEX FORAMINIFERA OF THE SILURIAN ROCKS.

Psammosphaera cava Moreman
Lagenammina sphaerica Moreman
Thurammina irregularis Moreman
Thurammina papillata Brady
Thurammina polygona Ireland, n. sp.
Thurammina sphaerica Ireland, n. sp.
Thurammina tubulata Moreman
Colonammina verruca Moreman
Ammodiscus, all observed species
Lituotuba, all observed species

INDEX FORAMINIFERA OF THE DEVONIAN ROCKS.

Psammophax bipartita Ireland, n. sp.
Stegnammina elongata Ireland, n. sp.
Ceratammina cornucopia Ireland, n. gen., n. sp.
Webbinella bipartita Ireland, n. sp.
Psammonyx maxwelli Ireland, n. sp.

The descriptions of species are arranged according to the classification of families and genera by Cushman. Only new forms are described, but all identified species are given in the check list (Table 1) which lists Foraminifera found in the samples from the outcrops in the Arbuckle Mountains and from oil wells. Only a few of the wells are listed because tabulation of 200 or more wells is unnecessary here.

The forms here described have been deposited with the collections of the Walker Museum of the University of Chicago. I

am greatly indebted to Dr. Carey Croneis of the University of Chicago for assistance and advice during the preparation and classification of this material.

DESCRIPTION OF SPECIES

Order FORAMINIFERA

Family RHIZAMMINIDAE Cushman, 1927

Genus BATHYSIPHON M. Sars, 1872

BATHYSIPHON CURVUS var. GRACILIS Ireland, n. var.

Figures A—*13*, *14*

Test elongate, very small, slightly curved, tubular; wall composed of very fine sand, well cemented; apertures at the ends of the tube. Dimensions, 0.30 by 0.02 mm (fig. A—*13*), 0.29 by 0.03 mm (fig. A—*14*).

Occurrence.—Chimney Hill limestone, figured specimens from depth of 3,405 feet in Homaokla-Caldwell no. 1, sec. 16, T. 5 N., R. 3 E., Oklahoma; also found in well group G.

Remarks.—This form is described as a variety since it resembles *B. curvus* Moreman, but it is very small, with no intermediate gradations in size.

BATHYSIPHON RUGOSUS Ireland, n. sp.

Figures A—*2*, *3*

Test free, elongate, tubular with a rough irregular surface; wall composed of well-cemented medium sized sand grains; apertures at the ends of the tube. Dimensions, 0.60 by 0.15 mm (fig. A—*2*); 0.58 by 0.10 mm (fig. A—*3*).

Occurrence.—Henryhouse shale at depth of 5,730 feet in Sinclair-Kennedy well no. 1, sec. 4, T. 13 N., R. I W. (fig. A—*2*); Henryhouse shale at Dougherty, Okla. (fig. A—*3*); also found in Haragan limestone at Dougherty, Okla., and from well groups F, G, and H.

Remarks.—The rough exterior of this form and the large size of the sand grains show it to be different from all other described species of *Bathysiphon*.

Family SACCAMMINIDAE Eimer and Fickert, 1899

Sub-Family PSAMMOSPHAERINAE Cushman

Genus PSAMMOSPHAERA F. E. Schultze, 1875

PSAMMOSPHAERA ANGULARIS Ireland, n. sp.

Figures A—*8*, *9*

Test free or attached, angular in outline;

TABLE I

Check List of Silurian and Devonian Microfauna from Central Oklahoma.

	A	B	C	D	E	F	G	H
Bathysiphon curvus Moreman	—	x	—	—	—	x	—	x
Bathysiphon curvus var. *gracilis* Ireland, n. var.	—	—	—	—	—	—	x	x
Bathysiphon diminutionis Moreman	x	—	x	—	x	x	—	x
Bathysiphon parallelus Dunn	x	—	x	—	x	x	—	x
Bathysiphon rugosus Ireland, n. sp.	x	—	x	—	x	x	x	x
Psammosphaera angularis Ireland, n. sp.	—	—	—	—	x	—	—	—
Psammosphaera cava Moreman	—	—	x	x	x	x	x	x
Psammosphaera excerpta Dunn	x	x	x	x	x	x	x	x
Psammosphaera gracilis Ireland, n. sp.	—	—	—	x	x	—	—	x
Psammosphaera magna Dunn	—	—	x	—	—	—	—	—
Psammophax bipartita Ireland, n. sp.	x	x	—	—	—	—	—	—
Sorosphaera multicella Dunn	—	—	—	—	—	x	—	—
Sorosphaera tricella Moreman	—	x	—	—	x	—	—	—
Stegnammina elongata Ireland, n. sp.	—	x	—	—	—	—	—	—
Ceratammina cornucopia Ireland, n. sp.	x	x	—	—	—	—	—	—
Saccammina moremani Ireland, n. sp.	—	—	—	—	x	—	—	—
Lagenammina distorta Ireland, n. sp.	—	—	x	—	x	—	—	—
Lagenammina sphaerica Moreman	—	—	x	—	x	—	x	—
Lagenammina stilla Dunn	—	—	x	—	x	—	—	—
Thurammina arcuata Moreman	—	—	—	—	x	—	—	—
Thurammina delicata Ireland, n. sp.	—	—	x	—	x	—	—	x
Thurammina echinata Dunn	—	—	—	—	x	—	—	x
Thurammina elliptica Moreman	—	—	—	—	x	—	—	x
Thurammina globosa Ireland, n. sp.	—	—	—	—	x	—	—	—
Thurammina irregularis Moreman	—	—	—	—	x	x	—	x
Thurammina papillata Brady	—	—	x	—	x	x	—	x
Thurammina papillata var. *monticulifera* Ireland, n. var.	—	—	x	—	x	—	—	—
Thurammina polygona Ireland, n. sp.	—	—	—	—	x	—	—	—
Thurammina subpapillata Ireland, n. sp.	—	—	x	—	x	—	—	—
Thurammina sphaerica Ireland, n. sp.	—	—	x	—	x	—	—	—
Thurammina subsphaerica Moreman	—	—	x	—	x	x	—	x
Thurammina transversalis Ireland, n. sp.	—	—	x	—	—	—	—	—
Thurammina triangularis Moreman	—	—	—	—	x	—	—	—
Thurammina tubulata Moreman	—	—	—	—	x	x	x	x
Webbinella bipartita Ireland, n. sp.	—	x	—	—	—	—	—	—
Webbinella coronata Ireland, n. sp.	—	—	—	x	—	—	—	—
Webbinella gibbosa Ireland, n. sp.	—	—	—	—	—	—	x	—
Colonammina conea Moreman	—	—	x	—	x	—	—	—
Colonammina verruca Moreman	—	—	—	—	x	—	—	—
Tholosina sedentata Ireland, n. sp.	—	—	—	—	—	—	x	x
Hyperammina harrisi Ireland, n. sp.	—	—	x	—	—	—	—	—
Ammodiscus abbreviatus Ireland, n. sp.	—	—	x	—	x	x	x	x
Ammodiscus constrictus Dunn	—	—	—	—	—	x	—	x
Ammodiscus exsertus Cushman	—	—	x	x	x	x	x	x
Ammodiscus exsertus var. *minutus* Ireland, n. var.	—	—	—	—	x	—	x	x
Ammodiscus incertus d'Orbigny	—	—	x	x	x	x	x	x
Glomospira westgatei Ireland, n. sp.	—	—	x	—	—	—	—	x
Glomospira siluriana Ireland, n. sp.	—	—	x	—	—	x	—	x
Lituotuba elongata Dunn	—	—	—	—	—	—	—	x
Lituotuba exserta Moreman	—	—	x	x	x	x	x	x
Lituotuba inflata Ireland, n. sp.	—	—	x	x	—	—	—	x
Psammonyx maxwelli Ireland, n. sp.	x	x	—	—	—	—	—	—
Bifurcammina bifurca Ireland, n. sp.	—	—	x	—	—	—	—	—
Bifurcammina conjuncta Ireland, n. sp.	—	—	x	—	—	—	—	—
Bifurcammina parallela Ireland, n. sp.	—	—	x	—	—	—	—	—

A, Devonian fauna from Dougherty, Okla., sec. 12, T. 2 S., R. 2 E.
B, Devonian fauna from Franks, Okla., sec. 7, T. 1 N., R. 7 E.
C, Silurian fauna from Dougherty, Okla.
D, Silurian fauna from Franks, Okla.
E, Silurian fauna on Lick Creek near Davis, Okla., sec. 24, T. 1 S., R. 1 E., and on Tulip Creek on U. S. Highway 77, sec. 25, T. 2 S., R. 1 E.
F, Silurian fauna from the following wells in Oklahoma: Ramsey-Julius no. 1, sec. 6, T. 4 N., R. 7 E.; Dixie-Sale no. 1, sec. 10, T. 4 N., R. 6 E.; McCullough-Chisholm no. 1, sec. 4, T. 4 N., R. 7 E.
G, Silurian fauna from the following wells in Oklahoma: Homaokla-Caldwell no. 1, sec. 16, T. 5 N., R. 3 E.; Independent-Moses no. 1, sec. 10, T. 5 N., R. 4 E.; Dixie-Norman no. 1, sec. 13, T. 5 N., R. 4 E.
H, Silurian fauna from the following wells in Oklahoma: Gypsy-Johnson no. 1, sec. 7, T. 7 N., R. 4 E.; Westheimer and Daube-Fried no. 3, sec. 24, T. 7 N., R. 4 E.; Phillips-Weldfeldt no. 1, sec. 26, T. 8 N., R. 4 E.

wall composed of poorly cemented sand grains of medium size; surface rough; apertures not apparent. Dimensions, 0.50 by 0.35 mm.

Occurrence.—Chimney Hill limestone on Lick Creek.

Remarks.—This species is too angular to be identified with *P. cava* Moreman and it lacks the projections and the multiple apertures of *Thurammina*. It is therefore described as a new species.

PSAMMOSPHAERA GRACILIS Ireland, n. sp.

Figures A—*10, 11*

Test free, spherical; wall composed of very fine sand well cemented; surface smooth but slightly rough on some specimens; apertures not apparent. Dimensions, 0.18 mm in diameter.

Occurrence.—Henryhouse shale at Franks, Okla.; St. Clair limestone at Cookson, Okla.; also from well group H.

Remarks.—This form is very small and delicate in appearance. It might be confused with *P. excerpta* Dunn, which has much larger sand grains. The forms from Cookson (fig. 1—*11*) are unusually fine-grained and are one of the few species found there. This form also resembles *Thurammina delicata* Ireland, n. sp., but lacks the minute projections of that form.

Genus PSAMMOPHAX Rhumbler, 1931

PSAMMOPHAX BIPARTITA Ireland, n. sp.

Figures A—*24, 25*

Test elongate, attached, composed of two chambers each convexly rounded on top, straight along the base with no basal evidence of the double chamber, in some cases wedge-shaped due to attachment in crevices; chambers strongly united with a distinct suture between; wall of medium sand grains poorly cemented; apertures not apparent. Dimensions, length, 0.37 mm; width, 0.18 mm; height, 0.12 mm.

Occurrence.—Haragan shale, Dougherty and Franks, Okla.

Remarks.—This species is common and one of the best index Foraminifera of the Devonian in this area. The form illustrated is one of the broader ones, many specimens being very narrow and wedge-shaped apparently due to attachment in crevices.

Sub-Family STEGNAMININAE Moreman, 1930

Genus STEGNAMMINA Moreman, 1930

STEGNAMMINA ELONGATA Ireland, n. sp.

Figure A—*17.*

Test free, elongate, cylindrical with rounded ends; walls composed of medium sand grains with much cement; surface smooth; aperture not apparent; color buff. Dimensions, length, 0.60 mm; diameter, 0.15 mm.

Occurrence.—Haragan shale, Franks, Okla.

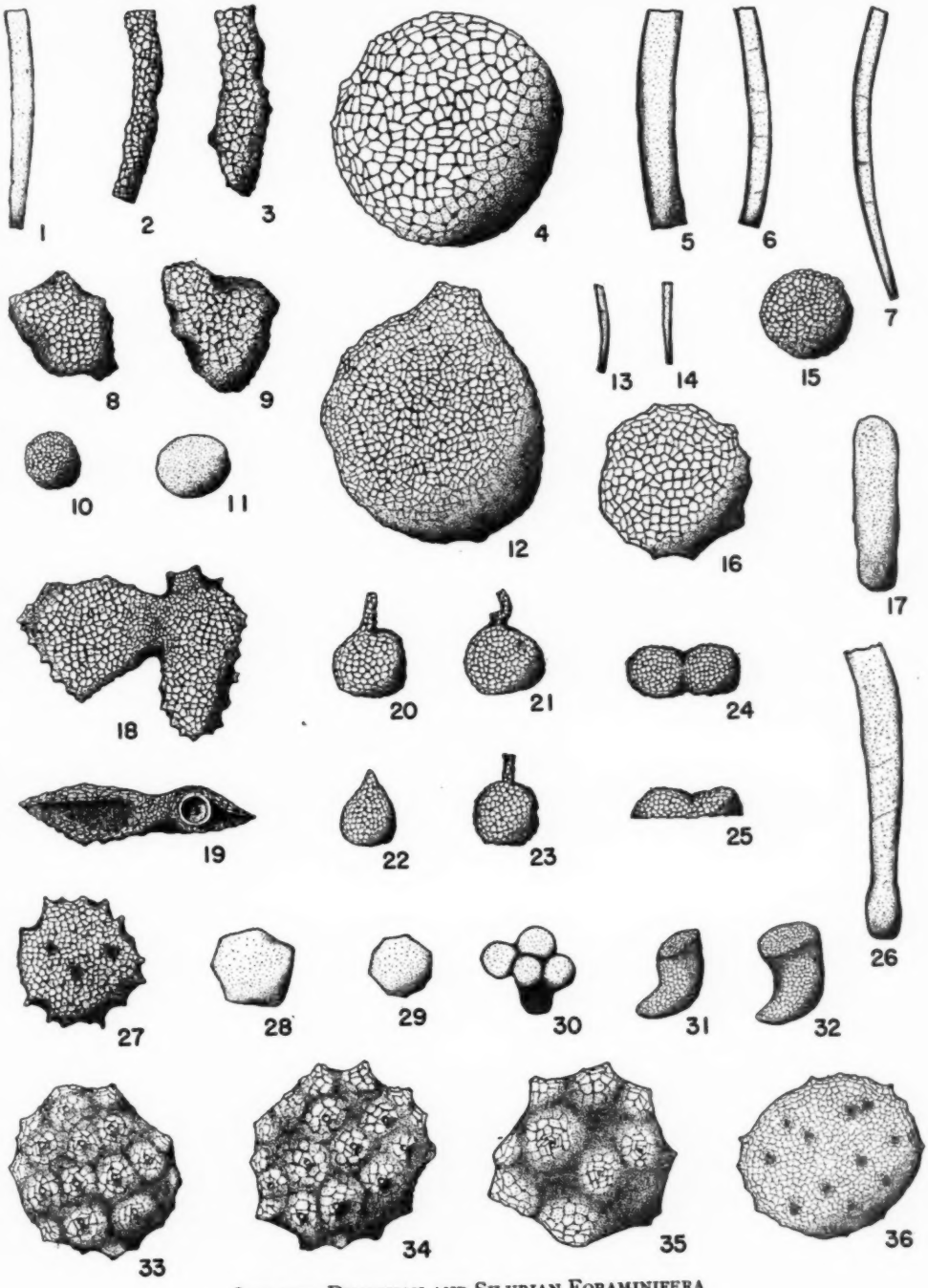
Remarks.—This species resembles the genotype, S. *cylindrica* Moreman, in general shape but does not have the rough surface and the flattened ends of that species, or the triangular cross-section of *S. triangularis* Moreman.

Genus CERATAMMINA Ireland, n. gen.

Test free, horn-shaped; wall composed of

EXPLANATION OF GROUP A FIGURES
(All ×40)

1—*Bathysiphon diminutionis* Moreman
2, 3—*Bathysiphon rugosus* Ireland, n. sp.
4—*Psammosphaera magna* Dunn
5, 6—*Bathysiphon parallelus* Dunn
7—*Bathysiphon curvus* Moreman
8, 9—*Psammosphaera angularis* Ireland, n. sp.
10, 11—*Psammosphaera gracilis* Ireland, n. sp.
12—*Saccammina moremani* Ireland, n. sp.
13, 14—*Bathysiphon curvus var. gracilis* Ireland, n. var.
15, 16—*Psammosphaera cava* Moreman
17—*Stegnammina elongata* Ireland, n. sp.
18—*Saccammina* sp.? Side view.
19—*Saccammina* sp.? Top view.
20, 21—*Lagenammina distorta* Ireland, n. sp.
22—*Lagenammina stilla* Dunn
23—*Lagenammina sphaerica* Moreman
24—*Psammophax bipartita* Ireland, n. sp. Top view.
25—*Psammophax bipartita* Ireland, n. sp. Side view.
26—*Hyperammina harrisi* Ireland, n. sp.
27—*Thurammina echinata* Dunn
28, 29—*Thurammina delicata* Ireland, n. sp.
30—*Sorophaera multicella* Dunn
31, 32—*Ceratammina cornucopia* Ireland, n. sp.
33, 34—*Thurammina sphaerica* Ireland, n. sp.
35—*Thurammina papillata var. monticulifera* Ireland, n. var.
36—*Thurammina subpapillata* Ireland, n. sp



IRELAND, DEVONIAN AND SILURIAN FORAMINIFERA

fine sand grains; surface smooth; aperture not apparent. Genotype, *Ceratammina cornucopia* Ireland, n. sp.

CERATAMMINA CORNUCOPIA Ireland, n. sp.

Figures A—*31*, *32*

Test free, horn-shaped; wall thin composed of fine sand grains well cemented; surface smooth to slightly rough; aperture not apparent but probably are multiple on the top surface; color white. Dimensions, height, 0.47 mm, diameter 0.27 mm (fig. A—*31*), height, 0.49 mm, diameter, 0.39 mm (fig. A—*32*).

Occurrence.—Haragan shale, Dougherty and Franks, Okla.

Remarks.—This species is a distinct Devonian form. The horn-shaped test is constant in all specimens.

GENUS SACCAMMINA M. Sars, 1869

SACCAMMINA MOREMANI Ireland, n. sp.

Figure A—*12*

Test free, spherical with a distinct neck; wall thick, composed of fine well cemented sand; aperture at the end of the neck. Dimensions, height, 0.86 mm; width, 0.77 mm.

Occurrence.—Chimney Hill limestone on Tulip Creek, Okla.

Remarks.—This species has about the same size and general appearance as the genotype, S. *sphaerica* Sars, but has fine-grained sand, whereas the genotype has coarse-grained sand. It is also from a very much older horizon.

SACAMMINA? sp.

Figures A—*18*, *19*

Only one specimen was found but the test is perfect and so distinct that it warrants description. Test free, composed of two chambers, one flat along the edges but bulbous in the center and attached to the second chamber by a constricted area; second chamber flattened, elongate, thin along one edge; wall thin, composed of medium to fine sand well cemented; surface very rough with many projections; aperture large and circular at the end of a short neck. Dimensions, greatest width, 0.74 mm; from aperture to the base vertically, 0.60 mm.

Occurrence.—Silurian, depth 4,072 feet in Westheimer and Daube Fried well no. 3, sec. 24, T. 7 N., R. 4 E., Oklahoma.

Genus LAGENAMMINA Rhumbler, 1911

LAGENAMMINA DISTORTA Ireland, n. sp.

Figures A—*20*, *21*

Test free, flask-shaped with a long twisted neck; wall composed of well cemented sand grains of medium to small size; aperture at the end of the neck. Dimensions, 0.35 mm, neck 0.10 mm (fig. A—*20*); 0.36 mm, neck 0.09 mm (fig. A—*21*).

Occurrence.—Chimney Hill limestone Dougherty, Okla., and on Lick Creek, Okla.

Remarks.—This form is similar to L. *sphaerica* Moreman in general shape, but the occurrence of the twisted neck suggests a different species. Associated species of *Lagenammina* do not have the distorted neck.

Genus THURAMMINA H. B. Brady, 1879

THURAMMINA DELICATA Ireland, n. sp.

Figures A—*28*, *29*

Test free, very small, spherical; wall thin composed of fine sand well cemented; surface unusually smooth, with a few low small nipplelike projections giving a slight polygonal outline; apertures at the ends of the projections; color white. Dimensions, 0.30 mm (fig. A—*28*); 0.20 mm (fig. A—*29*).

Occurrence.—Chimney Hill limestone Dougherty, Okla. (fig. A—*28*); Chimney Hill limestone at depth of 4,100 feet in Phillips-Weldfeldt well no. 1, sec. 26, T. 8 N., R. 4 E. (fig. A—*29*); also found on Tulip Creek in the Arbuckle Mountains.

Remarks.—The small size of this species is its outstanding feature. It resembles *Psammosphaera gracilis* Ireland, n. sp., but the presence of the small low projections differentiates it. It resembles the form described by Dunn as *P. parva*, but the Oklahoma form has definite apertures and is therefore a *Thurammina*. *P. parva* always carries a sponge spicule.

THURAMMINA GLOBOSA Ireland, n. sp.

Figures B—*5*, *6*

Test free, spherical, with four or five long delicate tubes projecting from the surface; wall thin, of medium sand grains lightly cemented; apertures at the ends of the

tubes. Dimensions, 0.24 to 0.26 mm for all forms.

Occurrence.—Chimney Hill limestone on Lick Creek and Tulip Creek, Okla.

Remarks.—These specimens resemble *T. irregularis* Moreman but occur in such large numbers with the spherical outlines rather than the irregular, angular configuration of *T. irregularis* that they appear to represent a definite species.

THURAMMINA PAPILLATA VAR MONTICULIFERA Ireland, n. var.

Figure A—*35*

Test free, spherical with a very rough surface due to many large uniformly spaced monticules of medium to large sand grains with strong cement; apertures at the ends of the monticules. Dimension, 0.68 mm.

Occurrence.—Chimney Hill limestone Dougherty, Okla., and along Tulip Creek, Okla.

Remarks.—This form is like *T. papillata* Brady in size and in the presence of papilli, but the rough surface, coarse grains, and massive appearing projections suggest that it is a different variety. It also resembles *T. sphaerica* Ireland, n. sp., which does not have the massive, distinctly uniformly spaced projections.

THURAMMINA POLYGONA Ireland, n. sp.

Figures B—*1, 2*

Test free, very angular, projections of various sizes with flat spaces between them. The projections are angular rather than nipplelike as in most *Thurammina;* wall composed of medium sand grains well cemented; apertures at the ends of the projections. Dimensions, length, 0.50 mm; width, 0.44 mm.

Occurrence.—Chimney Hill limestone on Tulip Creek, Okla.

Remarks.—This species resembles *T. irregularis* Moreman but the projections are angular rather than tubular. The large size and the flat spaces between projections give the specimens a distinct specific difference.

THURAMMINA SPHAERICA Ireland, n. sp.

Figures A—*33, 34*

Test free, spherical or nearly so, surface rough formed by numerous coarse elevations; wall thick, of medium sand grains well cemented; apertures at the end of the elevations; color buff. Diameters, 0.35 to 0.64 mm.

Occurrence.—Chimney Hill limestone from Lick Creek and Tulip Creek, Okla., and Dougherty, Okla.

Remarks.—*T. papillata* has finer sand, thin walls, and more delicate projections than this species, while *T. subsphaerica* Moreman is flattened. Species of *Psammosphaera* lack the rough elevations.

THURAMMINA SUBPAPILLATA Ireland, n. sp.

Figure A—*36*

Test free, spherical, with numerous minute short papilli; wall very thin, composed of fine sand well cemented; apertures at the ends of the papilli. Diameters, 0.55 to 0.58 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla., and on Lick Creek, Okla.

Remarks.—This species is like *T. papillata* Brady in size and in the presence of papillose projections, but the papilli of this species are minute, more delicate, and more numerous. The test is also very thin and fragile. The species could be mistaken for *Psammosphaera cava* Moreman if the small papilli were not observed. Only one specimen is figured as all of them were remarkably uniform in size and character.

THURAMMINA TRANSVERSALIS Ireland n. sp.

Figure B—*3*

Test free, subspherical, with a small hollow tube slightly curved running across the test and not opening into the interior at any point; wall of medium sand grains, poorly cemented; surface rough with small projections; apertures at the ends of projections. Dimensions, largest diameter, 0.60 mm, diameter of tube, 0.08 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla.

Remarks.—This is an unusual form, and due to the large size and poor cement, was not generally found entire. The presence of the tube through the center of the form distinguishes it from any other species.

Sub-Family WEBBINELLINAE Cushman

Genus WEBBINELLA Rhumbler, 1903

WEBBINELLA BIPARTITA

Ireland, n. sp.

Figures B—*14, 15*

Test attached, divided into two chambers with an anterior broad flange around the base, no interior opening between chambers; wall of very fine sand well cemented; surface smooth; apertures not apparent; color buff. Dimensions, length, 0.47 mm; width, 0.26 mm; left chamber, 0.10 mm high; right chamber, 0.14 mm high.

Occurrence.—Haragan limestone near Franks, Okla.

Remarks.—The characteristics of this species are outstanding, so that no other form is likely to be confused with it. It is important as a Devonian index form. The double chamber was the basis for describing the species, otherwise, it has all the characteristics of *Webblinella*. Only two specimens were found but they are so distinct that they warrant description.

WEBBINELLA CORONATA

Ireland, n. sp.

Figure B—*11*

Test attached, very large, convex above with a broad flattened flange at the base having spines projecting out at intervals; wall finely arenaceous; aperture not apparent; color white. Dimensions, 0.87 by 0.75 mm.

Occurrence.—Chimney Hill limestone near Franks, Okla.

Remarks.—This form is rare in occurrence. The large size, the broad flat flange, and the projecting spines are the basis for describing the species.

WEBBINELLA GIBBOSA

Ireland, n. sp.

Figures B—*23, 24*

Test attached, rounded above the plane of attachment, two chambers separated with a partition, chambers wider than long, very narrow exterior flange at the base where attached; wall of firmly cemented fine sand; aperture not apparent. Dimensions, length, 0.35 mm; width, 0.25 mm; height, 0.10 mm.

Occurrence.—Chimney Hill limestone at depth of 3,405 feet in Homaokla-Caldwell no. 1, sec. 16, T. 5 N., R. 3 E., Oklahoma.

Remarks.—This form is described as a new species on the basis of the narrow flange, the broad test, and the double chambers with only a slight depression between them on the exterior.

Genus THOLOSINA Rhumbler, 1895

THOLOSINA SEDENTATA

Ireland, n. sp.

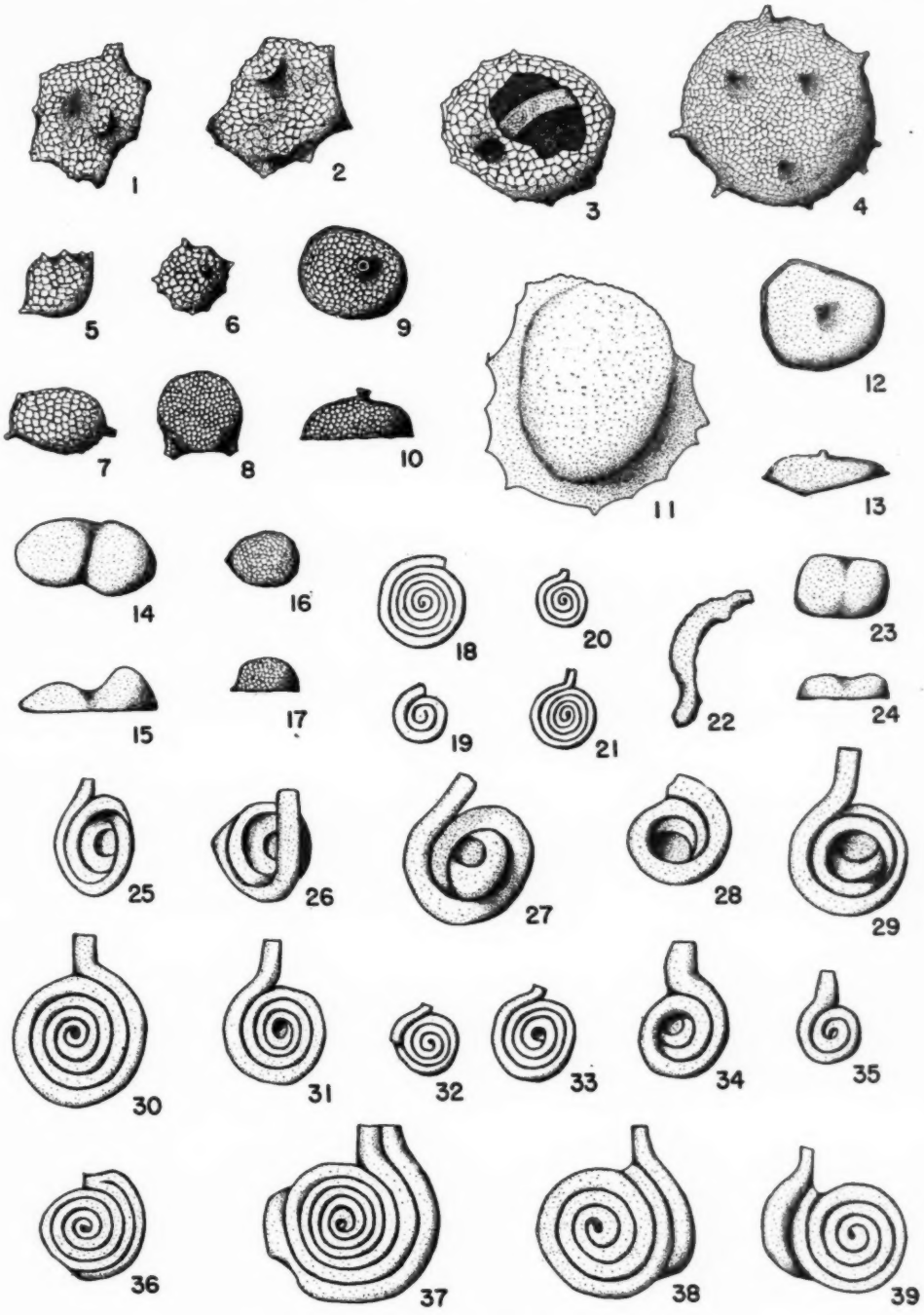
Figures B—*16, 17*

Test attached, slightly obovate, wall of small sand grains poorly cemented; surface slightly rough; aperture at the end of a short tube at one end close to the plane of

EXPLANATION OF GROUP B FIGURES

(All ×40)

1, 2—*Thurammina polygona* Ireland, n. sp.
3—*Thurammina transversalis* Ireland, n. sp.
4—*Thurammina tubulata* Moreman
5, 6—*Thurammina globosa* Ireland, n. sp.
7—*Thurammina elliptica* Moreman
8—*Thurammina arcuata* Moreman
9—*Colonammina verruca* Moreman. Top view.
10—*Colonammina verruca* Moreman. Side view.
11—*Webbinella coronata* Ireland, n. sp.
12—*Colonammina conea* Moreman. Top view.
13—*Colonammina conea* Moreman. Side view.
14—*Webbinella bipartita* Ireland, n. sp. Top view.
15—*Webbinella bipartita* Ireland, n. sp. Side view.
16—*Tholosina sedentata* Ireland, n. sp. Top view.
17—*Tholosina sedentata* Ireland, n. sp. Side view.
18—*Ammodiscus incertus* d'Orbigny. Microspheric form.
19—*Ammodiscus incertus* d'Orbigny. Megalospheric form.
20, 21—*Ammodiscus exsertus* var. *minutus* Ireland, n. var.
22—*Psammonyx maxwelli* Ireland, n. sp.
23—*Webbinella gibbosa* Ireland, n. sp. Top view.
24—*Webbinella gibbosa* Ireland, n. sp. Side view.
25, 26—*Glomospira westgatei* Ireland, n. sp.
27, 28—*Glomospira siluriana* Ireland, n. sp.
29—*Lituotuba exserta* Moreman
30, 31—*Ammodiscus exsertus* Cushman
32, 33—*Ammodiscus abbreviatus* Ireland, n. sp.
34, 35—*Lituotuba inflata* Ireland, n. sp.
36—*Bifurcammina conjuncta* Ireland, n. sp.
37—*Bifurcammina parallela* Ireland, n. sp.
38, 39—*Bifurcammina bifurca* Ireland, n. sp.



IRELAND, DEVONIAN AND SILURIAN FORAMINIFERA

attachment; color white. Dimensions, length, 0.25 mm; width, 0.18 mm.

Occurrence.—Chimney Hill limestone at depth of 3,405 feet in Homaokla-Caldwell no. 1, sec. 26, T. 5 N., R. 3 E., Oklahoma.

Remarks.—This form was unusually interesting because of a special feature on one specimen. When it was first observed there were several minute threads extending down from the base. These apparently were anchors of cement secreted down into cavities on the object to which it was attached. When the limestone matrix was dissolved the anchors were left, but they broke off when the specimen was moved for mounting. A sketch was made of their position but the feature is not described as part of the species as only the one specimen showed it.

Family HYPERAMMINIDAE Eimer and Fickert, 1899

Sub-Family HYPERAMMININAE Cushman

Genus HYPERAMMINA H. B. Brady, 1878

HYPERAMMINA HARRISI
Ireland, n. sp.
Figure A—*26*

Test free, curved, cylindrical, consisting of an ovoid proloculum and a tubular second chamber enlarging toward the end; wall of fine sand well cemented; surface smooth; aperture at the open end of the tube; color buff. Dimensions, length, 0.70 mm; diameter at the end, 0.12 mm; diameter of the proloculum, 0.08 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla.

Remarks.—This form lacks the pointed proloculum which some species have. A broken specimen with the proloculum absent is easily distinguished from *Bathysiphon* by its larger size and thick walls.

Family AMMODISCIDAE Rhumbler, 1895

Sub-Family AMMODISCINAE Cushman, 1910

Genus AMMODISCUS Reuss, 1861

AMMODISCUS ABBREVIATUS
Ireland, n. sp.
Figures B—*32*, *33*

Test free, planispirally coiled, consisting of an ovoid proloculum and a tubular second chamber ending in a very short abbreviated uncoiled portion at right angles to the coiling plane; wall of fine sand firmly cemented; aperture at the open end of the tube. Diameters, 0.21 mm (fig. 2—*32*); 0.26 mm (fig. 2—*33*).

Occurrence.—Chimney Hill limestone, Dougherty, Okla.; Lick Creek, Okla.; and well groups F, G, and H.

Remarks.—All forms seen are about the same size and without exception have the abbreviated neck. One form shows a definite suture on the neck, probably due to the cementing of a new portion after a break. It is not to be confused with *A. exsertus* Cushman, which has a longer neck and is larger. Though associated with *A. exsertus* there was no gradation in size or character that would indicate that the two were the same species.

AMMODISCUS EXSERTUS VAR. MINUTUS
Ireland, n. var.
Figures B—*20*, *21*

Test free, very small, coiled in a plane, consists of an ovoid proloculum and a tubular second chamber, which ends in a straight uncoiled portion at right angles to the coils; wall of fine sand well cemented; aperture at the end of the tube. Diameters, 0.14 to 0.20 mm.

Occurrence.—Chimney Hill limestone at depth of 5,740 feet in Sinclair-Kennedy well no. 1, sec. 4, T. 13 N., R. 1 W., Oklahoma.

Remarks.—This form is much like *A. exsertus* Cushman, but is very much smaller in size and has fewer coils. It is possible that it is a northern representative of the Arbuckle Mountain type of *A. exsertus*.

Genus GLOMOSPIRA Rzehak, 1888

GLOMOSPIRA WESTGATEI
Ireland, n. sp.
Figures B—*25*, *26*

Test free, tubular, coiled in various planes with the end of the tube projecting beyond and slightly bent away from the last point of attachment to the test; wall composed of fine sand well cemented; aperture at the end of the tube; color buff. Dimensions, height, 0.37 mm; width, 0.27 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla.

Remarks.—This species is differentiated by the many coils curved in various planes

and the manner in which the tube terminates. It resembles *G. siluriana* Ireland, n. sp., but has more coils which are less inflated.

GLOMOSPIRA SILURIANA
Ireland, n. sp.
Figures B—*27*, *28*

Test free, consisting of a proloculum and a tubular second chamber coiled in various planes with four or five whorls, tube large and inflated; wall of fine sand grains well cemented; aperture at the end of the tube generally slightly uncoiled near the termination. Diameters, 0.43 mm (fig. B—*27*); 0.36 mm (fig. B—*28*).

Occurrence.—Chimney Hill limestone, Dougherty, Okla.; also in well groups F and H.

Remarks.—This form should not be confused with a *Lituotuba* which has had the uncoiled portion broken away. It resembles *G. westgatei* Ireland, n. sp., but has fewer coils and a distinctly inflated tube.

Genus LITUOTUBA Rhumbler, 1895

LITUOTUBA INFLATA Ireland, n. sp.
Figures B—*34*, *35*

Test free, consisting of an ovoid proloculum and a tubular second chamber with three or four coils in various planes, the last whorl uncoiled at right angles to the test and equal in length to about two-thirds of the width of the test, the last coil and the terminal portion well inflated; wall of fine sand well cemented; surface smooth; aperture at the end of the tube, which is slightly constricted; color brown to buff. Dimensions, width, 0.32 mm; height, 0.50 mm.

Occurrence.—Chimney Hill limestone at depth of 4,072 feet in Westheimer and Daube-Fried no. 3, sec. 24, T. 7 N., R. 4 E., Oklahoma; also at Dougherty and Franks, Okla.

Remarks.—This species is differentiated by the highly inflated last coil. Dunn has described an *Ammodiscus inflatus* but it is coiled in one plane and is much less inflated.

Genus PSAMMONYX Doderlein, 1892

PSAMMONYX MAXWELLI Ireland, n. sp.
Figure B—*22*

Test free, elongate, composed of an ovoid proloculum and a long curving irregularly twisted tubular second chamber; wall of fine sand well cemented; aperture at the open end of the tube. Dimensions, length, 0.50 mm; diameter of the tube, 0.10 mm.

Occurrence.—Haragan limestone, Dougherty and Franks, Okla.

Remarks.—This is one of the few Devonian forms found in the Arbuckle Mountains. The elongate and twisted character of the tube with a distinct constriction above the proloculum are the distinguishing features.

Genus BIFURCAMMINA Ireland, n. gen.

Test free, composed of an ovoid proloculum and a tubular second chamber planispirally coiled in the early stages, the last coil divided into two tubes with various characteristics but always with a definite hump at the point where the added tube starts; wall of fine sand; apertures at the ends of the tubes. Genotype, *Bifurcammina bifurca.*

Remarks.—This new genus is created because of the persistent occurrence of the double tube of the last whorl. The double tube is not due to creasing during fossilization, as the suture line is too regular and is parallel with the other whorls. A collapsed tube would show irregular fractures on the test of most specimens. In my opinion, the organism would rebuild a broken whorl by extending it from the point of fracture, rather than parallel to a large portion of the last whorl. The second tube is not a substitute for a broken tube, for many specimens show complete unbroken double tubes. In one form the double tube has coalesced into a single aperture. This seems to indicate that two organisms did not live in the same test. Dunn found many double-tubed forms among his specimens but did not recognize them as a separate genus. Moreman found a bifurcating form and described it as questionably an *Ammodiscus.* All of the forms examined are regular in character and are not sports or anomalies. The specimens are quite abundant and in my opinion very distinct from *Ammodiscus* even though they are found associated.

BIFURCAMMINA BIFURCA
Ireland, n. sp.
Figures B—*38*, *39*

Test free, consisting of an ovoid proloculum and a tubular second chamber plani-

spirally coiled with the last coil enlarged into two tubes, with a hump marking the beginning of the added tube; the outer tube is slightly longer and is uncoiled away from the test and slightly constricted at the end; wall of fine sand well cemented; surface smooth; apertures at the ends of the tubes. Dimensions, width, 0.55 mm; height across coils, 0.42 mm; top aperture, 0.17 mm above last coil (fig. B—*38*); width, 0.49 mm; height across coils, 0.37 mm; top aperture, 0.17 mm above last coil (fig. B—*39*).

Occurrence.—Chimney Hill limestone, Dougherty and Lick Creek, Okla.

BIFURCAMMINA CONJUNCTA
Ireland, n. sp.
Figure B—*36*

Test free, consisting of a proloculum and a tubular second chamber planispirally coiled, the last coil branching into two tubes but reunited at the end into a single constricted opening with a slight flare; wall of fine sand well cemented; aperture a single circular opening at the end of the united tubes. Dimensions, 0.38 by 0.42 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla.

Remarks.—The fusing of the double tube into one aperture is the basis for naming the species.

BIFURCAMMINA PARALLELA
Ireland, n. sp.
Figure B—*37*

Test free, consisting of a proloculum and tubular second chamber, planispirally coiled with the last coil divided into two tubes which are parallel and turn outward at the end to form a short neck, both tubes large and the same height at the end; wall composed of fine sand well cemented; two apertures, one at the end of each tube. Dimensions, height, 0.50 mm; width, 0.57 mm; height of uncoiled portion, 0.12 mm; across double aperture, 0.15 mm.

Occurrence.—Chimney Hill limestone, Dougherty, Okla.

Remarks.—The outstanding features of this species are the equal level of the double tubes at the aperture, the large size, and the inflated character of the last whorls.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 203–210, 2 TEXT FIGS., MARCH, 1939

MISSISSIPPIAN FORMATIONS IN SOUTHERN ILLINOIS

H. N. CORYELL

ABSTRACT—The stratigraphic interval of the Mississippian-Pennsylvanian unconformity in part of Illinois is portrayed. The general attitude of the upper Chester beds, their possible areal distribution and relationship to the late Mississippian erosion surface is suggested. The use of microfossils in making inter-field stratigraphic correlation is illustrated, and definite relationship of the upper Mississippian beds in wells of Richland, Clay, and Wayne counties, Illinois, is established with outcrops of the Chester formations in Hardin County. Generic lists of the Ostracoda in a number of the Chester formations are included.

DURING early stages in the development of the Cisne—Clay City—Noble oil field, in Illinois, the geological staff of the Pure Oil Company, at Olney, Ill., found it necessary, in the midst of various duties requiring immediate attention, to develop a method by which deeply buried beds of sandstone, limestone, and shale of upper Mississippian age of one locality could be correlated with those of a neighboring area. Such a correlation problem, never simple, should be attacked with a complete array of available methods and theories. It was assumed that variations in the lithic facies should be expected, as well as irregularities in geographic distribution. When interbedding of sandstone, limestone, and shale with conspicuously definite boundaries appeared as the drill progressed downward, correlation by comparing lithic and mineral characteristics was naturally the first method tried. It proved very satisfactory in the Illinois basin. During further progress of the work the subsurface staff discovered that in several of the beds organic remains were conspicuously abundant, splendidly preserved and distinctly marked. The geographic distribution of these microfossils apparently paralleled and equalled very closely the lateral extent of the lithic facies that were designated as horizon markers or key beds.

An *Endothyra* horizon was one of the first fossil zones to be used, along with lithology, in making correlations. In it the fossils were abundant, small enough to come from the well in excellent condition, and easily identifiable. This horizon was assigned by James Mitchel to the Menard formation of the Chester, which Stuart Weller described in the Hardin County report of the Illinois State Geological Survey (1920). Mr. Mitchel also observed many fossils in other beds and indirectly made supplementary use of them in the subsurface studies and correlations.

It was this appearance of fossils that lead to formation of a plan by the Pure Oil Company to study the microfaunas of the Chester, and to make the faunal groups available for more definite service in the stratigraphic laboratory, supplementing the lithic studies.

Fossils should aid in correlating beds of different lithic facies on the basis of an organic principle that states that the biota of any particular locality commonly extends beyond the boundaries of its most favored environment.

DEVELOPMENT OF THE WORK

It was originally planned to work the samples of one well from each division of the new field in Richland, Clay and Wayne counties with considerable detail, by making a careful inspection of every possible fossil zone. After the work progressed it was discovered that the selection of three wells from the Cisne area instead of one was more feasible and afforded a better check. The first cuttings to be searched for microfossils were from a horizon in these wells that was correlated by comparison of the sediments. This was done in order to establish early in the work a definite relationship between the results of the lithologic and biologic methods. When a few horizons were positively determined in the Cisne wells, samples from other portions of these wells were studied, sometimes from only one well, sometimes

from another, and frequently from the same horizon in all three, when an additional check seemed advisable. In this manner a complete section of the fossil horizons in the Cisne section was studied, with "offset" checks on the correlation of the biologic zones and their relationship to the beds that

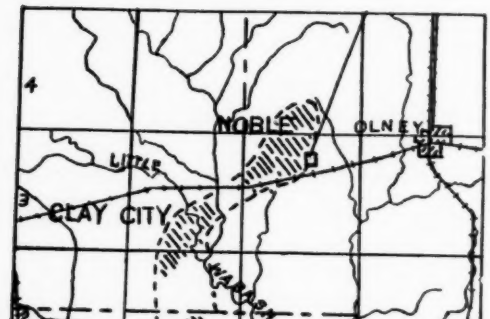


FIG. 1.—Map showing location of the Cisne-Clay City-Noble oil field (within broken enclosures) in Wayne, Clay, and Richland counties, Illinois.

had been correlated on the basis of lithologic similarity. Over this division of the field the geographic distribution of the Ostracoda and Foraminifera was found to be quite dependable.

The work was later extended to the Clay City area where samples from four wells were studied. Correlations were made between these wells, checking the distribution of the faunal zones and the relationship between the biologic and lithologic zones. At the same time stratigraphic horizons in the Clay City area were compared with those of the Cisne area, results being quite satisfactory. It began to appear possible to make detailed correlation of the upper Mississippian beds over a distance of 10 to 15 miles, by means of microfossils, which checked with other methods of identifying the beds.

The next step was to extend the biologic method to the Noble oil field, approximately 15 miles farther northeast. At the time when this study was begun, samples were available from only one well in this field, but the faunas of a few fossiliferous horizons, selected on the basis of lithologic correlations, were found to resemble corresponding assemblages from the other areas.

The apparent success of these paleontologic studies indicated that it should be used to check the oil field classification of beds above the producing "sand" with the section described by Weller in Hardin County. Numerous samples were obtained from the typical sections described by Weller and prepared for study by crushing the harder portions, washing out the finest debris, and sorting the material into graded sizes, always taking the precaution necessary to prevent destruction of the microfossils.

CONCLUSIONS

Study of the faunas from the several zones is not completed, but the interesting stratigraphic and structural conclusions resulting from the present survey are reported in a preliminary manner. The correlation chart was constructed by showing graphically the overlap of the Pennsylvanian beds upon successively older Chester formations as the Mississippian-Pennsylvanian contact is traced northward from Cisne in Wayne County, to Noble, in Richland County. The Kinkaid, belonging at the top of the Chester series, occurs only in the Cisne area, and it is the uppermost Mississippian formation in contact with the basal Pennsylvanian deposits. In the Clay City area, in Clay County, the Degonia and Clore formations are in contact with the Pennsylvanian beds, and in the Noble area the Palestine sandstone is the uppermost Mississippian formation. The lithological characters of the Mississippian formations from Cisne to Noble exhibit some variations but not of the magnitude expected in tracing a formation shoreward. The thickness variations are pronounced only in the upper Chester beds that lie just below the Pennsylvanian contact. The general attitude, areal distribution, and related lithic characters indicate that the upper surface of the Mississippian represents truncation by erosion rather than a conspicuous offlap. This indicates that the synclinal depression

in southeastern Illinois had been established definitely after Kinkaid deposition and before formation of the lowest Pennsylvanian bed.

STRATIGRAPHIC AND FAUNAL NOTES

Following is a list of the formations of upper Mississippian age in southern Illinois, with designation of the type locality for each, and indication of the position of lithologic correlation zones.

Degonia sandstone.—In the section north of Karbers Ridge, Hardin County, the Degonia consists of 50 feet of rather coarse-grained layers of sandstone interbedded with shale and shaly sandstone. In the wells, as outlined in the correlation table, it consists of 53 feet of red and green shale with considerable sandstone and calcareous sandy layers. The formation is present in the Cisne area below the "Kinkaid" limestone, whereas in the Clay City area it lies directly below the Pennsylvanian and is absent in the Noble area. The microfauna consists of a very few poorly preserved ostracodes. Identification of the Degonia is based upon its stratigraphic position and lithic characters.

UPPER MISSISSIPPIAN FORMATIONS IN SOUTHERN ILLINOIS

Formation	*Zones*	*Type Locality*
Kinkaid limestone	4	Kinkaid Creek, Jackson County, Southwest of Murphysboro, Ill.
Degonia sandstone	—	Degonia, Jackson County, Northeast of Cora, Ill.
Clore limestone	5	Clore, Randolph County, Southeast of Chester, Ill.
Palestine sandstone	—	New Palestine, Randolph County, Ill.
Menard limestone	6	Menard, Randolph County, Ill.
Waltersburg sandstone	—	Waltersburg, Pope County, Ill.
Vienna limestone	—	Vienna, Johnson County, Ill.
Tar Springs sandstone	—	Breckenridge County, Ky.
Glen Dean limestone	7	Breckenridge County, Ky.
Hardinsburg sandstone	—	Breckenridge County, Ky.
Golconda formation	8	Golconda, Pope County, Ill.
Cypress sandstone	—	Cypress Creek, Union County, Ill.
Paint Creek formation	—	Monroe and Randolph counties, Ill.
Bethel sandstone	—	Crittenden County, Ky.
Renault formation	9	Renault Township, Monroe County, Ill.
Shetlerville formation	—	Shetlerville, Hardin County, Ill.
Ste. Genevieve limestone	10	Ste. Genevieve, Mo.

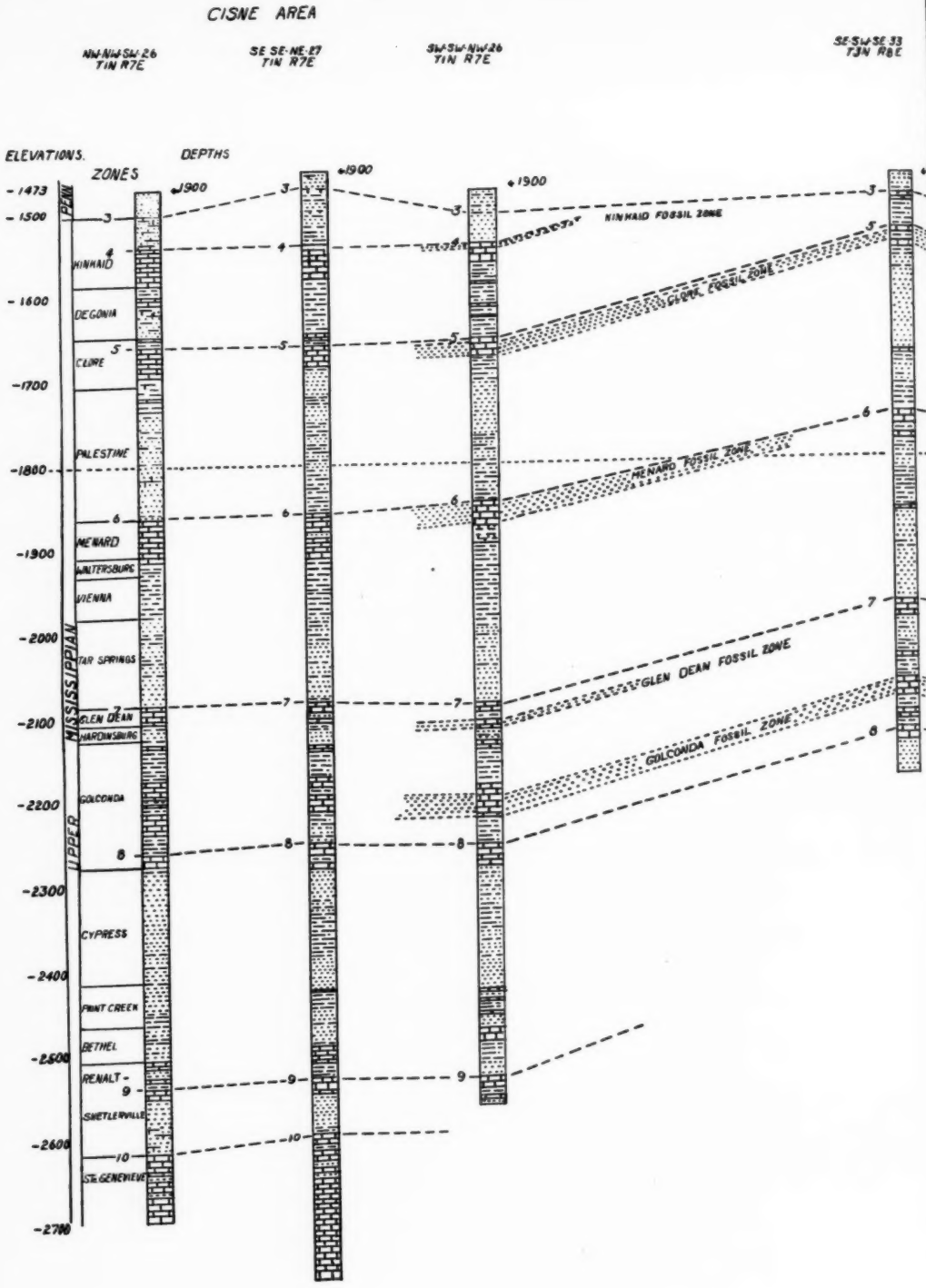
Kinkaid limestone (*Zone 4*).—In the accompanying well-log correlation chart, that portion of the section identified from its stratigraphic position as the Kinkaid limestone is also the key bed called Zone 4. It consists of 40 feet of limestone with interbedded green shale and cherty calcareous layers. The formation occurs only in the Cisne oil field, rising northward to the pre-Pennsylvanian erosional surface, shown as Zone 3 in the correlation chart, and disappearing before the southern boundary of the Clay City area is reached.

The faunal zone is shown on the chart as a stippled band. The microfossils occur in two layers, one at the top and one at the bottom of the limestone bed. In the upper zone, *Cavellina*, *Cytherella*, *Paraparchites*, *Silenites*, and a new ostracode genus are common, with the Foraminifera *Endothyra* and *Orobias* abundant. In the lower layer the two foraminiferal genera occur abundantly, while the ostracodes are absent.

The outcrop samples of the Kinkaid formation were unsatisfactory.

Clore limestone (*Zone 5*).—The Clore formation has been described in Hardin County as the thinnest formation of limestone and shale in the Chester, its thickness ranging from 20 to 30 feet. In the oil field (fig. 1), as much as 53 feet of beds are assigned to the Clore in the Cisne area, but the thickness decreases to 40 feet in the Clay City area. The Clore disappears from the section before the Noble area at the Arbuthnot well is reached.

The faunal zone of the Clore lies below and adjacent to the lithologic marker Zone 5. The Ostracoda consist most abundantly of *Amphissites*, *Bairdia*, *Carbonita?*, *Cytherella*, *Glyptopleura*, *Healdia*, *Jonesina*, *Paraparchites*, and a few new genera; common to rare are *Bairdianella*, *Bythocypris*, *Cavellina*, *Kirkbya*, *Kirkbyina*, *Monoceratina*,


CISNE AREA
NW-NW-SW 26 T1N R7E
SE SE-NE 27 T1N R7E
SW-SW-NW 26 T1N R7E
SE-SW-SE 33 T3N R8E
ELEVATIONS.
DEPTHS
ZONES
-1473
-1500
-1600
-1700
-1800
-1900
-2000
-2100
-2200
-2300
-2400
-2500
-2600
-2700
+1900
PENN.
MISSISSIPPIAN
UPPER
HINKAID
DEGONIA
CLORE
PALESTINE
MENARD
WALTERSBURG
VIENNA
TAR SPRINGS
GLEN DEAN
HARDINSBURG
GOLCONDA
CYPRESS
PAINT CREEK
BETHEL
RENAULT
SHETLERVILLE
STE. GENEVIEVE
HINKAID FOSSIL ZONE
CLORE FOSSIL ZONE
MENARD FOSSIL ZONE
GLEN DEAN FOSSIL ZONE
GOLCONDA FOSSIL ZONE

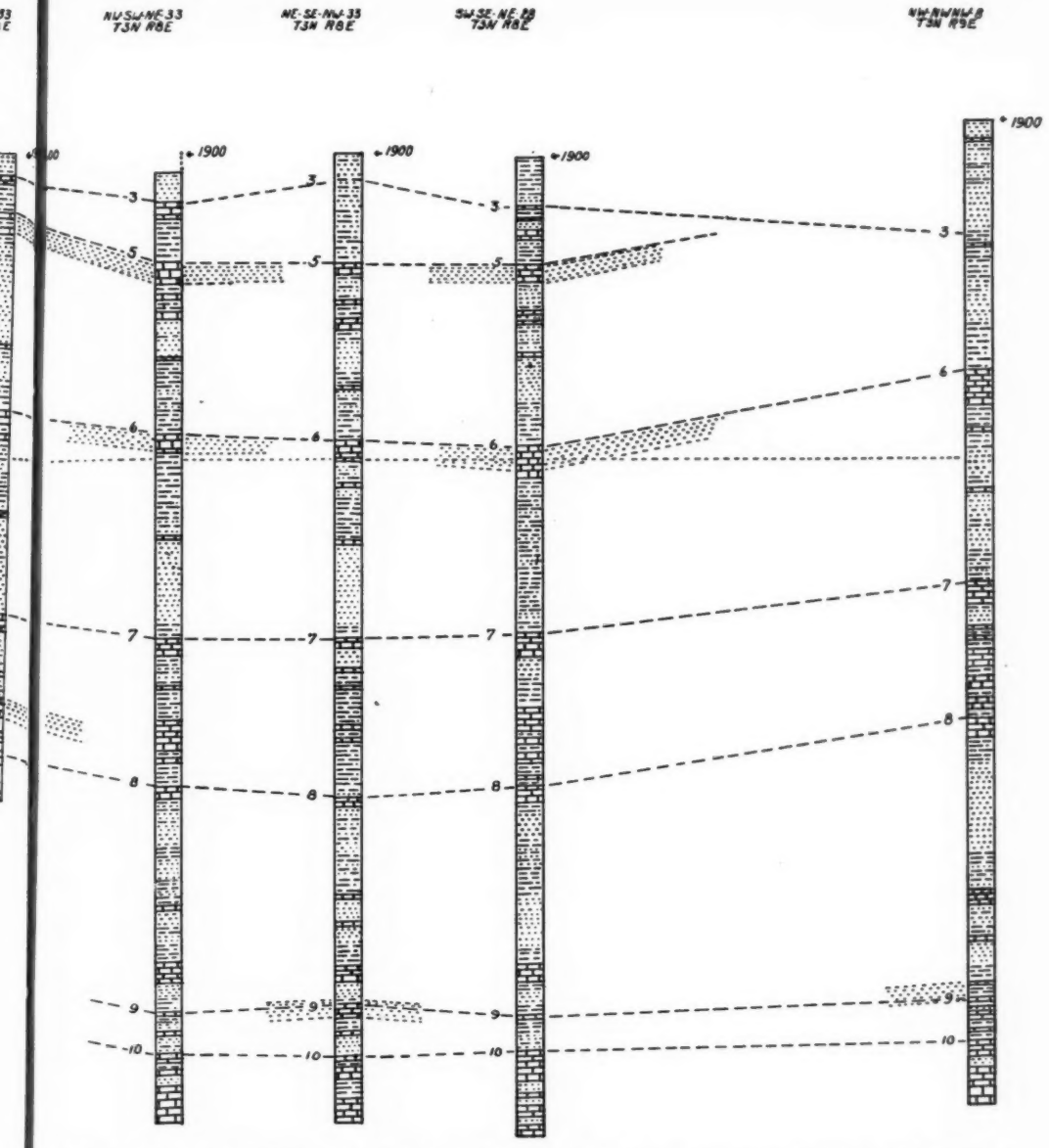


FIG. 2.—Correlation chart showing the upper Mississippian formations from the base of the Pennsylvanian to the Ste. Genevieve limestone in the Cisne-Clay City-Noble area of southern Illinois. Zone 3, the Mississippian-Pennsylvanian unconformity; zones 4 to 10, Lithologic key beds. Stippled bands show position of conspicuous fossil horizons.

Ponotocypris, *Primitia*, *Silenites*, and a few new genera. Among the Foraminifera specimens of *Endothyra* are abundant and *Schubertella* rare. The bryozoans *Archimedes*, *Fenestrellina*, *Rhombopora*, and *Streblotrypa* are common. Fragments of brachiopods, crinoids, gastropods, and pelecypods are abundant.

Clore outcrop samples from Hardin County contained a large microfauna, with an array of genera and species that left no doubt concerning our correlation of the subsurface fossil zone with the exposure described and mapped by Weller.

Palestine sandstone.—The upper shaly layers of the Palestine sandstone in the wells contain a few microfossils, including *Bairdia*, *Cavellina*, *Glyptopleura*, *Healdia*, *Jonesina*, *Kirkbyina*, *Paraparchites*, *Pontocypris*, *Endothyra*, and fragments of molluscoids, mollusks, and crinoids. The more sandy phase contains a few plant remains. The basal shaly bed contains very few representatives of the genera *Cytherella* and *Jonesina* and rare occurrences of conodonts.

Identification of the Palestine sandstone in the oil field was made on lithologic characters and stratigraphic position. This formation occurs beneath the Clore in the Cisne and Clay City areas but lies in contact with the basal Pennsylvanian in the Noble area.

Menard limestone (*Zone 6*).—In the Cisne area 44 feet of gray limestone and interbedded gray, green, and red shales have been assigned to the Menard limestone. The foraminiferal fauna is characterized by abundance of *Endothyra*. Among ostracode genera, *Bairdia*, *Cytherella*, *Healdia*, and *Jonesina* are rather common; *Glyptopleura* and *Pontocypris* are rare. Fragments of *Bythopora*, *Fenestrellina*, *Hallopora*, *Rhombopora*, and *Septopora* give evidences of the varied and prolific bryozoan fauna. Brachiopods and crinoids are also abundant. The fauna from the outcrop samples is distinctive and characteristic even though it is not so well preserved as that from the well cuttings.

The Menard faunal zone occurs in each area of the oil field and is one of the first used as a key bed in work on correlation.

Waltersburg sandstone.—In the Cisne area 22 feet of sandstone and interbedded shale have been assigned to the Waltersburg sandstone. Fossils are few. *Bairdia* and *Jonesina* occur, along with a few fragments of bryozoans and crinoids.

This formation was not seen in Hardin County, the identification in the wells being based on the published description and the position in the stratigraphic succession. The Waltersburg is present in all parts of the oil field.

Vienna limestone.—In the Cisne area 57 feet of limestone and shale have been assigned to the Vienna. Beds of this horizon occur also in the Clay City and Noble areas. The ostracode fauna is characterized by a great abundance of *Carbonita*-like forms near the middle of the deposit, along with a more widely distributed but less abundant occurrence of *Bairdia*, *Cavellina*, *Cytherella*, *Glyptopleura*, *Healdia*, *Jonesina*, and *Paraparchites*. Bryozoan fragments, representing *Fenestrellina*, *Rhombopora*, and *Septopora*, are common. Crinoid fragments are relatively abundant.

The Vienna limestone, not observed in Hardin County, is identified from the published description and stratigraphic position.

Tar Springs sandstone.—The Tar Springs sandstone has a thickness of 105 feet in the Cisne area. It is predominantly a sandstone, with a few thin shale beds and shale partings. Plant fragments are common. The identification of the Tar Springs is based on lithologic studies and stratigraphic occurrence. This sandstone is present in all areas of the oil field.

Glen Dean limestone (*Zone 7*).—The thickness of the Glen Dean ranges from 20 to 30 feet in the oil field. In some places a thin bed of red and green shale lies just above the limestone. Oolites are common in portions of the calcareous beds. The microfauna is more abundant in a somewhat thin zone than elsewhere in the formation, although specimens are common in all of the calcareous members. In the wells the most fossiliferous zone appears to be below the middle of the formation, whereas at the outcrop it is somewhat higher stratigraphically, lying nearer the middle of the deposit.

The fauna includes the ostracode genera *Amphissites*, *Bairdia*, *Bairdianella*, *Carbonita?*, *Cavellina*, *Cytherella*, *Glyptopleura*,

Glyptopleurina, Healdia, Jonesina, Kirkbya, Kirkbyina, Metacypris? Monoceratina, Moorites, Offa, Paraparchites, Pontocypris, Pseudoparaparchites, Sulcella, Xestoleberis, and several new genera. A few specimens of *Endothyra* represent the foraminiferal group. *Fenestrellina, Rhombopora, Stenopora,* and *Streblotrypa* are common. Fragments of brachiopods, gastropods, pelecypods, and crinoids vary in occurrence from common to abundant. The microfauna is characterized by the abundance of *Bairdia, Carbonita? Cytherella, Jonesina, Healdia,* and *Paraparchites.*

Hardinsburg sandstone.—The Hardinsburg appears in all areas of the oil field, ranging in thickness from 10 to 20 feet. In some places it is a shaly sandstone, the shale showing streaks of red, green, and gray colors. No fossils were collected from this formation. Its identification has been made on its lithologic characters and stratigraphic position.

Golconda formation (Zone 8).—The thickness of the Golconda ranges from 120 to 160 feet as designated in the well logs in the correlation chart. The upper beds are predominantly red, green, and gray calcareous shale, and the lower portion consists of limestone interbedded with red and green shale. Some of the limestone beds are distinctly oolitic. The limestone has furnished more microfossils than the shale both from the well cuttings and outcropping beds. The ostracodes include the following genera: *Amphissites, Bairdia, Carbonita? Cytherella, Entomoconchus, Glyptopleurina, Healdia, Jonesina, Macrocypris, Offa, Paraparchites, Pontocypris, Primitia, Silenites, Xestoleberis,* and several new genera. *Endothyra* specimens are abundant in the lower limestone member. *Rhombopora* and *Streblotrypa* are common. Fragments of corals, crinoids, gastropods, and pelecypods vary from common to abundant. In the upper limestone member minute oolitic septaria are very common.

This lower Chester fauna possesses a number of distinguishing characters among which are the abundance of *Bairdia, Carbonita?, Cytherella, Jonesina,* along with numerous *Endothyra.*

Cypress sandstone, Paint Creek shale, and Bethel sandstone.—These three formations in the wells of the oil field occupy an interval ranging from 220 to 270 feet. The upper 130 to 150 feet is predominantly a sandstone with interbedded shaly facies. This has been referred to the Cypress of Weller's section in Hardin County on the basis of stratigraphic position and lithologic characters. No fossils were identified.

The next lower 40 to 50 feet consist of red and green shale with limy and sandy beds. They occupy the Paint Creek portion of the section and resemble characters of the section described by Weller. The outcrop samples and well cuttings have yielded very few specimens of fossils that are distinctive.

The Bethel consists of 20 to 40 feet of sandstone with a minor amount of red and green shale. Its identification in the oil field area is based on the description of the lithology and its position in the stratigraphic column.

Renault and Shetlerville formations (Zone 9).—These two formations were described by Weller without emphasis on their differentiation in the several sections discussed in the Hardin County report. The lithology is variable when the section is considered as a unit. The upper portion consists of a limestone (Renault) that is generally oolitic. In a few of the wells it has been interpreted as a limy shale.

The Shetlerville is a more shaly formation with thin-bedded limestone and sandy layers. The limy shale and the limestone beds are very fossiliferous. The ostracode genera *Bairdia, Healdia, Jonesina, Paraparchites, Seminolites* are very abundant in both the Renault and Shetlerville. Five new genera are present. Other genera are *Bythocypris, Cornigella, Cytherella, Glyptopleura, Moorites, Sulcella,* and *Youngiella.* Fragments of *Rhombopora, Streblotrypa,* and the various fenestelloids are abundant. Crinoid fragments are numerous but gastropod and pelecypod remains are few.

The relative abundance of the various genera can be used to differentiate the Renault and Shetlerville. However, individual species present a greater number of distinctions.

Ste. Genevieve limestone (Zone 10).—Since the Ste. Genevieve limestone contains the producing horizon in the Cisne-Clay City-Noble oil field, there has been no

particular effort by the drilling companies to penetrate the total thickness of the formation. The bottom of one of the wells plotted in the correlation chart enters a cherty limestone that may be near the top of the St. Louis formation. Since there are cherty horizons within the Ste. Genevieve it is doubtful that the base of the Ste. Genevieve has been reached here, even though more than 170 feet of limestone deposits belonging to this formation were penetrated.

No identifiable microfossils have been discovered in the oolitic beds either from the outcrop samples or from well cuttings. The identification of the Ste. Genevieve is based upon mineralogic and lithologic characters similar to those of the outcrops and on stratigraphic position.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 211–213, 2 TEXT FIGS., MARCH, 1939

UNUSUAL OCCURRENCE OF ISOTELUS GIGAS DEKAY IN THE BROMIDE FORMATION (ORDOVICIAN) OF SOUTHERN OKLAHOMA

L. R. LAUDON

ABSTRACT—Several thousand specimens of *Isotelus gigas* DeKay have been gathered from a single colony of trilobites which was discovered by a field party of students from the University of Tulsa during March, 1937, in the upper portion of the Bromide formation of Ordovician age, in southern Oklahoma. The fossils are crowded closely together, often overlapping on the limestone slabs, and are in an excellent state of preservation.

SCATTERED fragments of *Isotelus gigas* occur abundantly throughout the Bromide formation, Middle Ordovician, in southern Oklahoma. Occasionally a few more or less complete specimens are found. The occurrence of excellently preserved specimens in any abundance, however, is decidedly unusual.

During March 1937, in company with a large group of students from the University of Tulsa, I visited a well known exposure of the Bromide formation at "Rock Crossing" in the south Criner Hills, a few miles southwest of Ardmore, Okla. (fig. 1). Several students working on the left bank of the stream discovered loose pieces of limestone carrying partially complete, weathered specimens of *Isotelus gigas* in unusual numbers. Detailed work in the immediate vicinity soon uncovered fresh slabs whose surfaces were literally covered with complete specimens of this trilobite. Careful examination demonstrated that the fossils occurred in one very thin marly layer between two rather thin limestone beds. The thin marly layer adhered to the under surface of the upper limestone bed, which facilitated the removal of the fossils. The Bromide formation dips rather sharply at the place of discovery of these fossils so that the fossiliferous layer is soon carried below the level of the stream. The marly layer containing the fossils was weathered and soft in the upper foot or two of material, but farther down it could be worked only with greatest difficulty. The colony could be traced along the strike of the formation for a distance of about 18 feet.

The party of students returned to the area equipped with quarrying tools and carefully removed the ledges overlying the layer carrying the fossils. Slabs carrying the fossils were then removed from the pit as far down as the hardness of the stone would permit working. The material taken from the lower unweathered portion of the colony is so hard that it is very difficult to prepare the fossils.

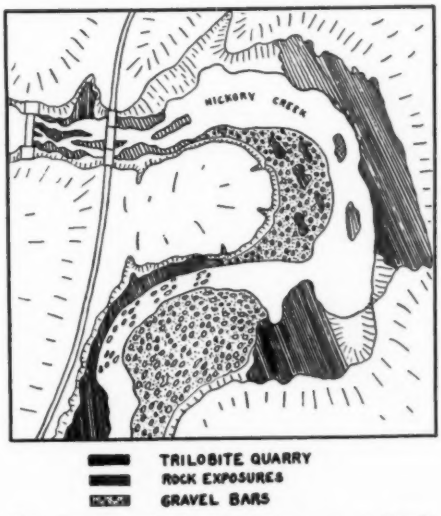

FIG. 1.—Detailed map of the area at Rock Crossing, in sec. 35, T. 1 E., R. 5 S., southwest of Ardmore, Okla., showing location of the ledge from which the fossils were taken. The area shown in map is about one-fourth of a square mile.

The fossils occur near the base of the upper dense member of the Bromide formation. The location of the trilobite-bearing

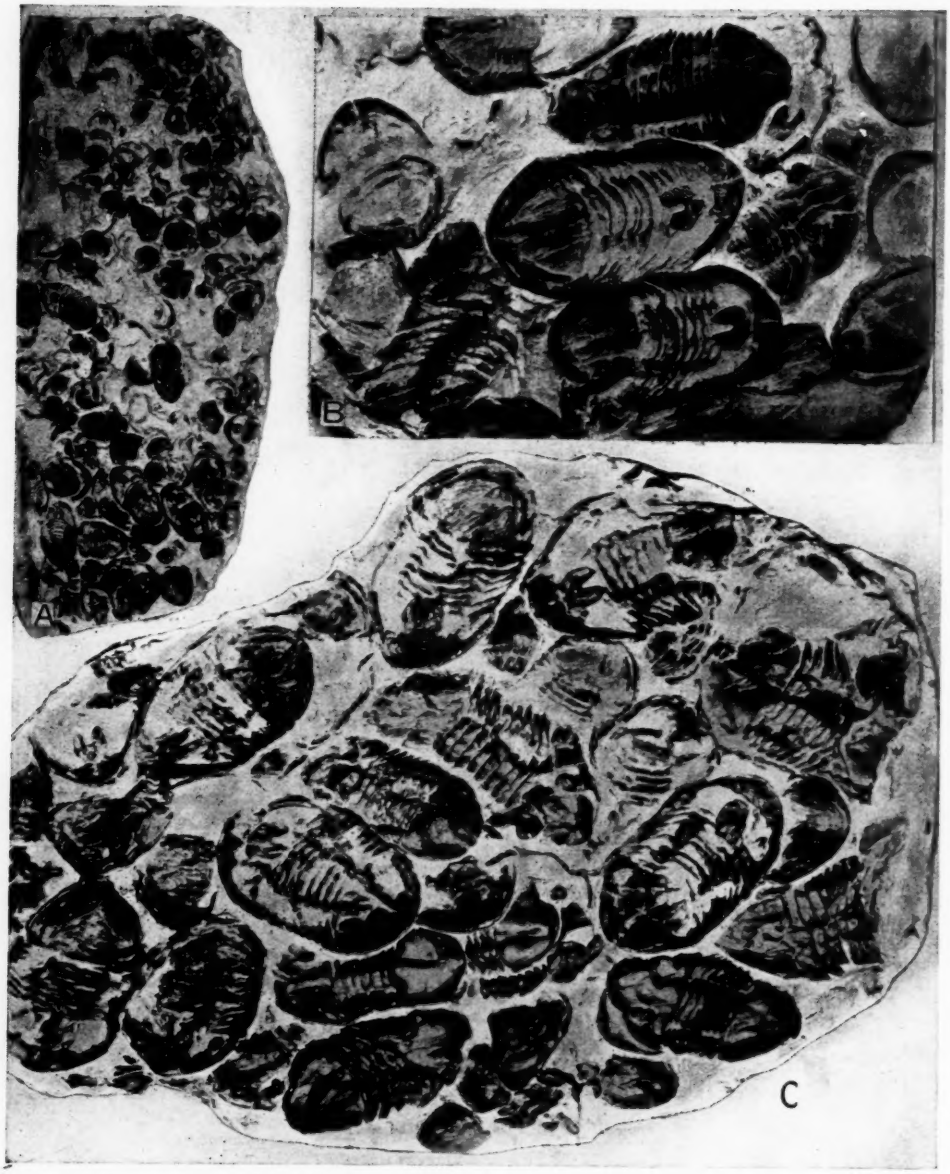

FIG. 2.—Slabs of limestone from the Bromide formation (Middle Ordovician), of southern Oklahoma, bearing numerous specimens of the trilobite, *Isotelus gigas* DeKay. *A*, Slab carrying remains of 111 specimens; maximum length of slab 20 inches, width 8 inches; ×0.2. *B*, Slab showing two excellent specimens with hypostoma in place; ×0.6. *C*, Unusually fine slab carrying remains of 36 specimens; maximum length of slab 11 inches, width 6 inches, ×0.4.

ledge is on the left bank of Hickory creek, about eight miles southwest of Ardmore, Okla., in the south Criner Hills. The exposure is located in about the center of sec. 35, T. 1 E., R. 5 S.

Preparation of the fossils for display is

slow because of the unusually fine grain and moderate hardness of the marl surrounding the fossils. The fossils themselves are quite badly cracked, necessitating patient careful cleaning. The slab shown in Figure 2A has a maximum length of 20 inches and a maximum width of 8 inches; remains of 111 specimens of *Isotelus gigas* have been exposed on its surface. About half of the specimens are oriented in the ventral position so that the hypostoma is commonly exposed in position.

Fossils are still available in the ledge where quarrying operations ceased. The hardness of the rock in which the fossils are imbedded makes it inadvisable to quarry further.

L. R. LAUDON, UNIVERSITY OF TULSA, TULSA, OKLA. MANUSCRIPT RECEIVED BY THE EDITOR, DECEMBER 19, 1938.

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OSTRACODA OF THE CLORE LIMESTONE, UPPER MISSISSIPPIAN, OF ILLINOIS

H. N. CORYELL AND SAMUEL C. JOHNSON

ABSTRACT.—The Clore limestone, an upper Chester formation of the Mississippian of Illinois, contains many species of Ostracoda. Twenty-seven species, classified in sixteen different genera are given here. Twenty-four of the species and seven of the genera are described as new.

THE MATERIAL described in this paper was collected during the summer of 1937 from an outcrop of the Clore limestone 1½ miles north of Karbers Ridge, in Hardin County, Illinois.

The Chester group, of Late Mississippian age, attains a thickness of from 900 to 1,200 feet in Hardin County. The Clore is the thinnest of the upper Chester limestones, being probably nowhere more than 20 to 30 feet thick, and in many places less. The thickness at the collecting locality could not be determined since neither contact was visible. A zone approximately two inches in thickness, occurring about 10 feet below the top of the exposure, yielded this faunule.

The ostracode zone consists of a gray argillaceous limestone with shaly parting. Ostracodes are often so numerous that a dozen or more can be observed on a square inch surface of the matrix. The preservation is excellent, on the whole. In washing the samples, however, it was found that many of the more ornamented forms, especially the Glyptopleurids, would not break entirely free of the calcareous matrix. With proper care, however, such forms can be freed and cleaned with a fine needle.

This paper follows usage of H. L. Geis in the orientation of *Glyptopleura* and *Sansabella* and in the inclusion of these two genera in the family Glyptopleuridae Girty, 1910. The orientation of *Beyrichiopsis* is reversed, so that the greatest thickness falls in the posterior portion. The present orientation of *Jonesina* and *Kloendenella* has been retained to avoid confusion.

Several species common to the Amsden formation, as described by Morey, are present in this faunule, and it is probable that further studies may suggest a more definite correlation. Our collection from the Clore has yielded 7 new genera and 24 new species, which are described in the following pages. Most of the new names are drawn from Nordic mythology.

The genera *Cavellina* and *Bythocypris* are profusely represented, and ontogenetic series of each have been assembled. The *Cavellina* series show that the posterior swelling is present in the early stages of the individual, as well as in the mature forms, and is not therefore entirely indicative of sexual dimorphism.

The authors express their thanks to John E. Steinman for his photographic reproduction of the specimens.

SYSTEMATIC DESCRIPTIONS

Family LERERDITELLIDAE Ulrich and Bassler, 1908

Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES NICKLESI (Ulrich)

Plate 25, figure 1

Leperditia Nicklesi ULRICH, *1891*, Cincinnati Soc. Nat. Hist., Jour., vol. 13, p. 200, pl. 18, fig. 1*a–e*.

This species is rather common in the Clore limestone. Several large specimens were found and numerous smaller ones, which appear to belong to the same species. The "eye" tubercle, when present, occurs only on the left valve.

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus JONESINA Ulrich and Bassler, 1908

JONESINA PUNCTA Morey

Plate 26, figure 3

Jonesina? puncta MOREY, *1935*, *Jour. Paleontology*, vol. 9, no. 6, p. 476, pl. 54, fig. 1.

This species is fairly common in the Clore formation.

JONESINA ODINI Coryell and Johnson, n. sp.

Plate 26, figures 1a, b

Carapace small, subrhomboidal, inequivalved; left valve the larger and overlapping the right on the free margins; overlap most conspicuous ventrally; hingeline straight, slightly impressed; greatest length slightly below the median line; greatest height perpendicular to the posterior cardinal angle. Surface marked by a median sulcus, open dorsally and bordered otherwise by a U-shaped swelling, which is set off from the more compressed margins of the carapace; a slight sulcus is present in this swelling just below the posterior cardinal angle; a fine tubercle occurs just below the anterior cardinal angle on the periphery. Surface sparsely punctate. Dorsal view bilobate with ends tapered.

The name is derived from Odin, the supreme deity of the later Norse pantheon.

Length, 0.75 mm, height, 0.45 mm, thickness, 0.35 mm.

Holotype.—Columbia University micropaleontological collections.

Genus KLOEDENELLA Ulrich and Bassler, 1908

KLOEDENELLA SIGURDI Coryell and Johnson, n. sp.

Plate 26, figure 2

This is an exact mirror image of *Jonesina puncta* Morey and can be differentiated by the reversal of overlap.

Length, 0.60 mm, height, 0.35 mm, thickness, 0.35 mm.

Holotype.—Columbia University Micropaleontological Collections.

Genus BEYRICHIOPSIS Jones and Kirkby, 1886

BEYRICHIOPSIS THORI Coryell and Johnson, n. sp.

Plate 25, figures 2 a, b, c, d

Carapace large, subrectangular, inequivalved; right valve the larger and overlapping the left along the ventral and posterior margins; anterior margin not overlapped, except for a strong denticular overlap at the cardinal angle; dorsum and venter straight and subparallel; extremities broadly and evenly rounded; greatest length median; greatest thickness in the post-dorsal quarter. Carapace marked by a deep sulcus slightly anterior to midlength which sets off the tumid posterior portion from the smaller anterior lobe, which merges gently into a ventral swelling. A slight sulcus is present just below and behind the anterior cardinal angle. The right valve is conspicuously marked by a marginal rim, which rises on the dorsum just in front of the posterior swelling and runs around the anterior extremity where, near the ventral margin, at the point where the valvular overlap begins, it becomes a submarginal ridge and continues as such posteriorly until it reaches a point below the sulcus, where it bends abruptly and joins the periphery in the postventral third. This ridge gives a sharp, steep outline to the anterior ventral portion. Dorsal view lobate, cuneate.

A syntype, preserved in the matrix, shows that at least the anterior margin was frilled. This frill is a delicate, vertically striated affair. A remnant of such a frill was observed on another syntype. The orientation of this genus has been reversed so that the more obese end becomes the posterior.

The name is derived from Thor, god of thunder.

Length, 1.10 mm, height, 0.65 mm, thickness, 0.65 mm.

Holotype.—Columbia University micropaleontological collection.

BEYRICHIOPSIS BRYNHILDAE Coryell and Johnson, n. sp.

Plate 26, figures 4a, b, c

Carapace large, subrectangular, inequivalved; right valve the larger and overlapping the left around the free margins; dorsum and venter straight, subparallel; posterior greatly inflated, somewhat less so in the postventral region; slightly lower, but coalescing with the inflated posterior, is an elongate swelling, which runs forward in the ventral portion; a rounded node sits astride this in the anterior portion, thus defining a wide, deep, dorsal median sulcus; an inconspicuous sulcus is present just in front of the anterior swelling; the anterior margin shows a few slight striations as though a frill had been present and broken off.

Only one specimen of this species has been

found. It differs from *Beyrichiopsis thori* in the greater ratio of length to height, in the anterior overlap, in the sharply defined anterior node, and in the lack of the submarginal ridge in the anterior ventral portion.

The name is derived from Brynhild, heroine of the Volsunga saga.

Length, 1.02 mm, height, 0.45 mm, thickness, 0.44 mm.

Holotype.—Columbia University micropaleontological collections.

Genus KLOEDENELLINA Coryell and Johnson, n. gen.

Subrhomboidal, strongly inequivalved Ostracoda; right valve the larger and overlapping the left; dorsum straight, more or less channeled; cardinal angles subequal; surface marked by a strong dorso-median sulcus and a rather inconspicuous anterior sulcus; the right valve is strongly grooved along the ventral margin between the periphery and the convexity of the valve, which passes into a flattened border along the extremities. Surface more or less punctate.

Genotype, *Kloedenellina Heimdalli* Coryell and Johnson, n. sp.

Remarks.—This genus is distinguishable from *Kloedenella* by the subequal cardinal angles, the channeled hinge, the grooved venter of the right valve, and prominence of the punctae.

KLOEDENELLINA HEIMDALLI Coryell and Johnson, n. sp.

Plate 26, figures 5a, b

Carapace subrhomboidal, strongly inequivalved; right valve larger and overlapping the left along the free margins; overlap strongest ventrally; hingeline long, straight; cardinal angles subequal; anterior broadly rounded; posterior broadly rounded, truncated dorsally; greatest length median; greatest height anterior; greatest thickness just below the sulcus. Surface marked by a deep sulcus slightly anterior to midlength, and a rather indistinct sulcus below the anterior cardinal angle, which widens dorsally lending a lobate appearance to the carapace. The right valve is strongly grooved along the ventral margin between the periphery and the convexity of the valve; this groove passes into a flattened border along the extremities. Dorsal aspect bilobate with tapered ends.

The name is derived from Heimdall, warder of Asgard, who kills and is killed by Loki.

Length, 0.92 mm, height, 0.57 mm, thickness, 0.40 mm.

Holotype.—Columbia University micropaleontological collections.

Family ACRONOTELLIDAE Swartz, 1936

Genus LOKIUS Coryell and Johnson, n. gen.

Subrhomboidal, inequivalved Ostracoda; right valve overlapping the left along the free margins. Surface marked by a dorso-median sulcus bounded on either side by low swellings and with a conspicuous alar protuberance in the central portion of the valve below midheight.

Genotype, *Lokius sigynae* Coryell and Johnson, n. sp.

Remarks.—This genus is easily distinguished from the closely related *Monoceratina* Roth by the node-bounded sulcus and the alar projection, in place of a ventrally directed spine. The outline and surface ornamentation differ totally from *Acronotella* Ulrich and Bassler.

The name is derived from Loki, god of discord and mischief.

LOKIUS SIGYNAE Coryell and Johnson

Plate 26, figures 6a, b, c

Carapace subrhomboidal, inequivalved; right valve the larger and overlapping the left along the free margins; dorsum straight, venter straight and slightly oblique to the hingeline; anterior broadly curved; greatest curvature ventral; posterior broadly rounded; cardinal angles obtuse; greatest length along the median line; greatest height one fourth the length from the anterior extremity. Surface marked by a sulcus, slightly anterior to midlength, bordered anteriorly and posteriorly by low swellings, the anterior one the more conspicuous, which drop suddenly dorsally and merge ventrally with a very conspicuous forward-sloping, winglike protuberance, which is confined to the midportions of the valves midway between the median line and the

venter. Dorsal view fusiform-semilobate; compressed anteriorly and posteriorly. Ventral aspect fusiform.

The name is derived from Sigyn, the wife of Loki.

Length, 0.75 mm, height, 0.43 mm, thickness, 0.35 mm.

Holotype.—Columbia University micropaleontological collections.

Family KIRKBYIDAE Ulrich and Bassler, 1923

Genus GILLINA Coryell and Johnson, n. gen.

Subrectangular, inequivalved Ostracoda, the right valve the larger and overlapping the left. The even convexity of the valves is marked with punctae and a dorso-median sulcus. A flattened, unornamented border on the free margins gives the carapace a keeled affect.

Genotype, *Gillina vitharri* Coryell and Johnson, n. sp.

This genus is differentiated from *Kirkbyella* by the punctae and the even convexity of the valves.

It is named in honor of J. Willard Gill.

GILLINA VITHARRI Coryell and Johnson, n. sp.

Plate 26, figure 7

Carapace large, subrectangular inequivalved; right valve the larger and overlapping the left around the periphery of the free margins; hingeline long, straight; venter long and straight, subparallel with the dorsum and rounding evenly into the ends; anterior cardinal angle obtuse; anterior obliquely rounded with the greatest extension below midheight; posterior evenly rounded with the greatest extension about median; the rather even convexity of the valves is bordered on the free edges by a flattened margin, and cut in the dorsal half, just in front of midlength, by a deep sulcus; surface of valves punctate, especially so centrally.

The name is derived from Vitharr, son of Odin.

Length, 0.75 mm, height, 0.45 mm, thickness, 0.27 mm.

Holotype.—Columbia University micropaleontological collections.

Family GLYPTOPLEURIDAE Girty, 1910

Genus GLYPTOPLEURA Girty 1910

GLYPTOPLEURA SKATHIAE Coryell and Johnson, n. sp.

Plate 25, figure 4

Carapace large subrectangular, inequivalved; right valve the larger and overlapping the left; dorsum and venter straight and subparallel; anterior broadly and evenly rounded; posterior broadly rounded with the greatest curvature above the median line. Greatest length median. Sides nearly parallel in dorsal view; ends blunt; hinge slightly impressed and broadly margined.

Surface marked by two pits slightly anterior to the center, the lower on the median line and the other above; marginal rim conspicuous except posteriorly. Five primary and one secondary costae slope forward; the first primary ridge cuts between the two pits; a secondary costa arises anterior to the upper pit and loops around to connect with the fourth primary ridge below, coalescing with the first ridge as it passes. The second, third and fifth ridges parallel these but may not connect.

The name is derived from Skathi, a goddess of Finnish origin, wife of Njorth.

Length, 1.23 mm, height, 0.73 mm, thickness, 0.50 mm.

Holotype.—Columbia University micropaleontological collections.

GLYPTOPLEURA NERTHUSAE Coryell and Johnson, n. sp.

Plate 25, figure 5a, b

Carapace large, subrhomboidal inequivalved; right valve larger and overlapping the left; dorsum and venter straight; subparallel; anterior broadly rounded with the strongest curvature below the median line; posterior broadly rounded with the strongest curvature above midheight; greatest length along the median line; greatest thickness at midheight one fourth the length from the posterior. Dorsal view cuneate; ends angled, the posterior more widely than the anterior; posterior swelling pronounced; hinge contact narrowly bordered, somewhat impressed; posterior view subcircular.

Surface marked by two pits; the lower located at about the midlength on the

median line; the upper slightly anterior to the one below. A marginal rim, passing into a marginal costa ventrally, fades posteriorly; seven inosculating costae slope forward; the first and third are broken by the pits; the anterior end of the first costa bends down, parallels the anterior extremity, and merges with the seventh costa; in this curvature it may connect with the anterior ends of the second, fourth and sixth ridges; posteriorly the fourth and fifth costae may or may not connect in a narrow loop just behind the greatest thickness; other ridges above and below bend as though to coalesce but fade out.

The name is derived from Nerthus, a goddess of peace and fertility.

Length, 1.24 mm, height, 0.74 mm, thickness 0.65 mm.

Holotype.—Columbia University micropaleontological collections.

GLYPTOPLEURA VALKYRIAE Coryell and Johnson, n. sp.

Plate 25, figure 6

Carapace large subrhomboidal, inequivalved; right valve larger and overlapping the left; dorsum straight with the exception of a slight rise slightly posterior to midlength; venter straight, subparallel to the hingeline; anterior broadly and evenly rounded; posterior broadly rounded with the strongest curvature above midheight. In dorsal view, sides subparallel; anterior blunt; posterior cuneate; hinge area somewhat channeled, especially over the dorsal hump.

Surface marked by two pits; the lower the deeper and slightly anterior to the middle on the line of greatest length; the other just above and less well defined. A marginal rim, strongest along dorsum and venter, is indistinct anteriorly and fades out posteriorly. Five primary costa rise in the posterior quarter and slope forward; the uppermost passes between the pits, loops the anterior, and connects with the third costa, below which there are two other subparallel ridges; the second costae cuts just under the lower pit but does not connect with the loop. In the posterior there are two short, subordinate costae which alternate with the first three primary ridges; the lower one of these secondary ridges is often continued anteriorly with or without a break. A secondary costa rises anterior to the upper pit and slopes forward where it may merge with the loop.

The name is derived from Valkyria, a maiden who conducts worthy heroes to Valhalla.

Length, 1.25 mm, height, 0.75 mm, thickness, 0.53 mm.

Holotype.—Columbia University micropaleontological collections.

Genus GLYPTOPLEURITES Coryell and Johnson, n. gen.

Carapace small, with straight hingeline; convexity of the valves margined by a steep slope, higher in anterior part than posterior; remainder of the convexity somewhat flattened and marked with posterior longitudinally arranged loops, with the outer loop of the flattened crest margining an anterior node. The entire margin of the valve is more or less distinctly marked with an adjacent or subparallel ridge.

Genotype, *Glyptopleurites tyri* Coryell and Johnson, n. sp.

EXPLANATION OF PLATE 25

FIGS. *1—Paraparchites nicklesi* (Ulrich). Right valve. (p. 214)

2a–d—Beyrichiopsis thori Coryell and Johnson, n. sp. *a*, Right, *b*, left, *c*, ventral, and *d*, dorsal views, ×30. (p. 215)

3a–b—Sansabella fenriri Coryell and Johnson, n. sp. *a*, Right, and *b*, dorsal views, ×25. (p. 220)

4—Glyptopleura skathiae Coryell and Johnson, n. sp. Right view, ×30. (p. 217)

5a, b—Glyptopleura nerthusae Coryell and Johnson, n. sp. *a*, Right, and *b*, dorsal views, ×30. (p. 217)

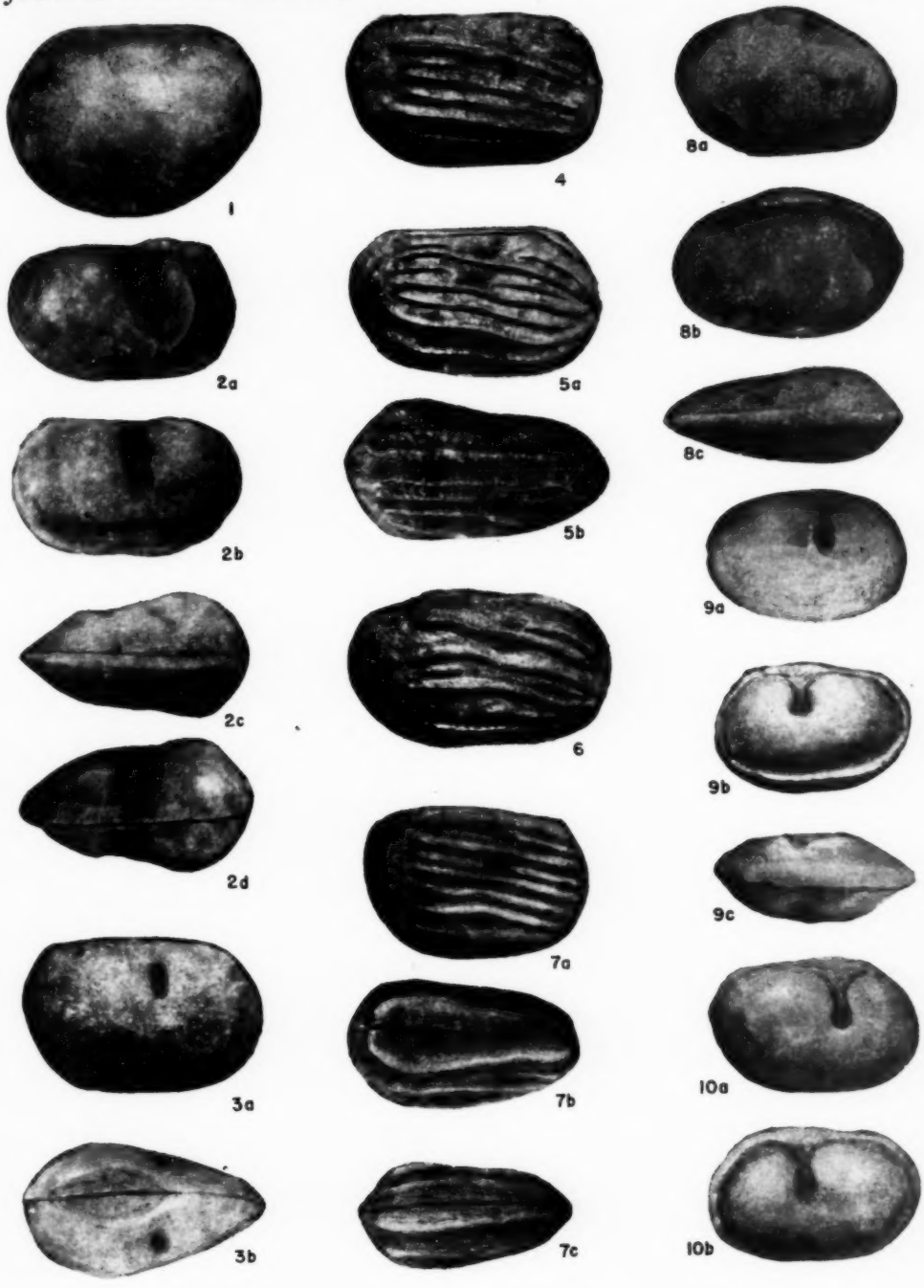
6—Glyptopleura valkyriae Coryell and Johnson, n. sp. Right view, ×30. (p. 218)

7a, b—Glyptopleura friggae Coryell and Johnson, n. sp. *a*, Right, and *b*, dorsal views, ×25. (p. 220)

8a–c—Cavellina ithunnae Coryell and Johnson, n. sp. *a*, Right, *b*, left, and *c*, dorsal views, ×30. (p. 223)

9a–c—Sargentina allani Coryell and Johnson, n. g., n. sp. *a*, Right, *b*, left, and *c*, dorsal views, ×30. (p. 223)

10a–c—Sargentina forsetii Coryell and Johnson, n. g., n. sp. *a*, Right, *b*, left, and *c*, dorsal views, ×30. (p. 224)



Coryell and Johnson, Mississippian Ostracoda

UNIV. OF MICH.

GLYPTOPLEURITES TYRI Coryell and Johnson, n. sp.

Plate 26, figures 10a, b, c

Carapace subrectangular, inequivalved; right valve larger and overlapping the left; greatest overlap ventral. Dorsum and venter straight and subparallel; anterior evenly rounded and obtusely angled dorsally; posterior broadly rounded. Greatest length along the median line; greatest thickness on the midline one fourth the distance from the posterior extremity. Dorsal view cuneate; posterior view subcircular.

Carapace bordered by a marginal rim, fading on the posterior extremity. The most conspicuous surface feature of this species is the hemispherical swelling of the posterior one third. The lowermost ridge arises anterior to the swelling, passes forward and loops up into the first ridge, which runs back and completely around the swollen portion, rises so as to cut the posterior end of the lowermost ridge, and passes forward to connect again with that ridge just behind the anterior loop. The second costa rises part way up on the node and goes forward where it fades just behind the loop. An almost vertical ridge arises from the first costa just above and behind the anterior loop and connects with the marginal rim just behind the anterior cardinal angle.

The name is derived from Tyr, a sky and war god of ancient Teutonic people.

Length, 0.78 mm, height, 0.44 mm, thickness, 0.33 mm.

Holotype.—Columbia University micropaleontological collections.

GLYPTOPLEURA SAGAE Coryell and Johnson, n. sp.

Plate 26, figure 16

Carapace small, subrhomboidal, inequivalved; right valve larger and overlapping the left. Dorsum straight; venter straight centrally with broadly rounded ends. Anterior broadly and evenly rounded; posterior broadly rounded with the more gently curved portion below the median line. Greatest length median; greatest height near the center; greatest thickness in the posterior ventral quarter. Dorsal view roughly cuneate, somewhat lobate; compressed posteriorly.

Surface marked by a median sulcus, bounded posteriorly by a large swelling, which merges evenly into the swollen ventral portion of the carapace, and anteriorly by a small node. A marginal ridge bounds the dorsum and venter and appears inconspicuously anteriorly and posteriorly. Surface ornamented by four well defined costae and one subordinate ridge. The secondary ridge slopes down from the slight hollow in front of the anterior node. The first primary ridge rises in the posterior-dorsal quarter, across the posterior swelling, does not completely lose its identity as it crosses the sulcus, equally divides the anterior knob and passes almost to the anterior margin, where it loops into the third primary ridge. This third costa slopes anteriorly along the ventral swelling. Enclosed in this loop and touching it anteriorly, is a somewhat less conspicuous ridge, which arises just below the pitlike base of the sulcus. Paralleling the venter, and midway between it and the ridge above, is a shorter ridge which fades anteriorly and posteriorly.

The name is derived from Saga, a goddess and seeress described as drinking from golden beakers with Odin.

Length, 0.84 mm, height, 0.51. mm, thickness, 0.37 mm.

Holotype.—Columbia University micropaleontological collections.

GLYPTOPLEURA FREYJAE Coryell and Johnson, n. sp.

Plate 26, figure 17

Carapace subrhomboidal, inequivalved; right valve larger and overlapping the left; dorsum straight; venter slightly convex with pronounced forward swing; anterior broadly rounded with the strongest curvature below the median line; posterior obliquely rounded with sharpest curvature dorsal. Greatest length is somewhat above the median line; greatest height located one third to one quarter the length from the anterior extremity; greatest thickness is on the third primary ridge slightly posterior to the midlength of the valves. In dorsal view sides are subparallel, with the exception of the swelling in the post-ventral portion; ends cuneate; hinge not channeled.

Surface marked by two pits; the lower about midlength and slightly above mid-

height; the upper, shallower and directly above. A marginal rim loops the anterior from the dorsum and becomes a marginal costa ventrally, fading posteriorly. Four primary costae rise in the posterior one fourth and slope forward; the uppermost passes between the pits, to connect with the third ridge, which crowns a rather distinct ventral swelling; the second ridge arises slightly anterior to the first and third costae, and may or may not reach the loop; the fourth costa rises on a line with the second and ends about one third the distance from the anterior. A secondary ridge, which rises just anterior to the upper pit, may reach the loop. There is usually a second subordinate ridge, of varying intensity and length, between the second and third primary costae.

The name is derived from Freyja, goddess of love and beauty.

Length, 0.83 mm, height, 0.50 mm, thickness, 0.65 mm.

Holotype.—Columbia University micropaleontological collections.

GLYPTOPLEURA FRIGGAE
Coryell and Johnson, n. sp.
Plate 25, figures 7a, b

Carapace large subrhomboidal inequivalved; right valve larger and overlapping the left. Dorsum straight; anterior broadly and evenly rounded; posterior rounded with broadest curvature ventral; greatest length along the median line or slightly above; greatest height located one fourth the length from the posterior extremity; greatest thickness posterior, median at midheight. In dorsal view the channeled hinge area forms an asymmetrical oval, which is widest one quarter the hinge length from the posterior and tapers more gently anteriorly than posteriorly. Posterior view suboval.

Surface marked by two pits; the upper just below the dorsum, the other below and a little behind the first. A marginal ridge, cutting below and acentuating the anterior cardinal angle, parallels the outline of the carapace and loses its identity posteriorly. Six primary ornamental ridges slope forward from their point of origin in the posterior one quarter; the first of these passes between the two pits; the second is broken by the lower pit. A secondary ridge arises anterior to the upper pit and loops around to join the anterior of the fifth main ridge, coalescing with the first primary costa *en route*. A short ridge may be present between the fifth and sixth primary costae.

The name is derived from Frigga, wife of Odin.

Length, 1.10 mm, height, 0.71 mm, thickness, 0.59 mm.

Holotype.—Columbia University micropaleontological collections.

Genus SANSABELLA Roundy, 1926
SANSABELLA GUNNARI
Coryell and Johnson, n. sp.
Plate 26, figure 11a, b.

Carapace small, subelliptical, inequivalved; right valve larger and overlapping the left on the free margins; hingeline straight, channeled, especially so in the posterior portion; anterior broadly and evenly rounded; posterior broadly rounded with the greatest curvature ventral; venter slightly convex; greatest length median; greatest height about one third of the length from the posterior extremity; greatest thickness at or just behind midlength. Carapace marked by a very indistinct sulcus in the dorsal half just in front of the greatest thickness.

The name is derived fromGunnar, brother of Gundrun and husband of Brynhild.

Length, 0.78 mm, height, 0.54 mm, thickness, 0.51 mm.

Holotype.—Columbia University micropaleontological collections.

SANSABELLA FENRIRI
Coryell and Johnson, n. sp.
Plate 25, figures 3a, b.

Carapace large, subrhomboidal, inequivalved; right valve larger and overlapping the left along the free margins; hingeline straight, deeply channeled in the posterior portion; the dorsal margin very gently convex; anterior broadly rounded; posterior evenly rounded above and somewhat more broadly curved below midheight; median ventral apparently nearly straight; greatest length nearly at midheight; greatest height one fourth the length from the posterior extremity; the posterior half of the carapace is conspicuously swollen, almost to roundness; a distinct sulcus is present just in front

of the obesity; dorsal aspect cuneate, swollen posteriorly.

The name is derived from Fenrir, the wolf who fights with Tyr.

Length, 1.19 mm, height, 0.76 mm, thickness, 0.59 mm.

Holotype.—Columbia University micropaleontological collections.

Genus REVERSABELLA
Coryell and Johnson, n. gen.

Carapace small, subrhomboidal; greatest thickness in the posterior one half; left valve larger than the right, overlapping on ends and ventral margin; hingeline straight, equal in both valves and, in part, slightly lower than the margins of the two valves, giving a channeled appearance in dorsal view.

Genotype, *Reversabella njorthi* Coryell and Johnson, n. sp.

Remarks.—In following H. L. Geis in the orientation of *Sansabella* Roundy, with the right valve the larger, this genus is erected to receive forms which have reversed overlap.

REVERSABELLA REVERSA (Morey)

Sansabella reversa MOREY, *1935, Jour. Paleontology*, vol. 9, no. 6, p. 476, pl. 54, f. 6.
Plate 26, figure 12a, b.

Carapace subovate in lateral view; strongly inflated; dorsal margins of valves very gently convex, that of the left valve more so than that of the right; ends broadly rounded; posterior extremity well above midheight; anterior extremity below midheight; ventral margin broadly convex; maximum height and thickness in back of midlength; dorsum channeled, most strongly so in posterior half; hinge straight, equal to about five eighths of the length of the carapace; valves strongly convex, sides curving strongly to posterior margin and evenly and gently to anterior margin; left valve much larger than right and peripheral to it on all margins, slightly so on dorsal margin, strongly so on ventral margin; overlap on free margins strong, particularly so on ventral margin.

The foregoing description is taken from that of P. S. Morey with changes made in the orientation to conform with that of the genus *Reversabella*.

REVERSABELLA NJORTHI
Coryell and Johnson, n. sp.
Plate 26, figure 8

Carapace subovate, inequivalved; left valve larger and overlapping the right along the ends and ventral margin; hingeline straight, about three fourths the length of the carapace; impressed, most conspicuously so in the posterior portion; dorsum gently arcuate; anterior broadly rounded with the greatest extremity below midheight; posterior broadly rounded with the greatest extremity above midheight; venter broadly arcuate; greatest height one third of the length from the posterior extremity; greatest length about median; greatest thickness on line of maximum height. Surface marked by a pit, of varying intensity, in the dorsoanterior quarter of the valve.

This species is differentiated from *Reversabella reversa* (Morey) by the presence of the pit.

The name is derived from Njorth, protector of seafarers, who controls the winds.

Length, 0.70 mm, height, 0.49 mm, thickness, 0.36 mm.

Holotype.—Columbia University micropaleontological collections.

Genus CERATOPLEURINA
Coryell and Johnson, n. gen.

Subrhomboidal to subrectangular, inequivalved Ostracoda; right valve the larger and overlapping the left. Carapace marked by one or two pits and a variable number of costae, which slope forward, and all, or some of which end posteriorly in pronounced spines. Free margin with or without marginal rim or border.

Genotype, *Ceratopleurina mimiri* Coryell and Johnson, n. sp.

Remarks.—This genus differs from *Glyptopleura* Girty in the spiny termination of the costae.

Glyptopleura spinosa (Jones and Kirkby), 1867, is referred to this genus.

CERATOPLEURINA MIMIRI
Coryell and Johnson, n. sp.
Plate 26, figure 9a, b.

Carapace subrhomboidal, inequivalved; right valve larger and overlapping the left; dorsum straight; venter slightly convex

with a pronounced forward, ventral extension; anterior obliquely rounded with the strongest curvature below midheight; posterior obliquely rounded with strongest curvature dorsal. Greatest length about median; greatest height central; greatest thickness slightly below the center of the valve; dorsal view subovate; posterior alar projections pronounced.

Carapace marked by a pit, slightly anterior to center near the line of greatest length and bordered anteriorly by a low node. Surface is ornamented with four forward sloping ridges; the upper one in the posterior quarter in a spine, and from this projection it runs forward, above the pit and over the low rounded node, and apparently loops down to connect with the third ridge, which passes along the ventral swelling. The second and fourth costae are less well-defined and are independent of the loop.

The name is derived from Mimir, a giant who knows all the past and future.

Length, 0.88 mm, height, 0.49 mm, thickness, 0.43 mm.

Holotype.—Columbia University micropaleontological collections.

Genus BYTHOCYPRIS Brady 1880

BYTHOCYPRIS ULLI

Coryell and Johnson, n. sp.

Plate 26, figure 13a, b.

Carapace small; dorsum highly arched, subangular at apex, which occurs approximately at midlength; venter straight, rounding into the ends; posterior broadly and evenly rounded; anterior angulated at contact with antero-dorsal slope, broadly and evenly rounded into venter; greatest anterior extension at point of angulation above midheight; greatest posterior extension slightly below midheight; greatest thickness slightly anterior to midlength; overlap fairly strong dorsally and ventrally.

The highly arched dorsum and the profile of the margin anterior are distinctive.

The name is derived from Ull, one of the Aesir.

Length, 0.65 mm, height, 0.38 mm, thickness, 0.27 mm.

Holotype.—Columbia University micropaleontological collections.

Genus MACROCYPRIS Brady, 1867

MACROCYPRIS REGINNI

Coryell and Johnson, n. sp.

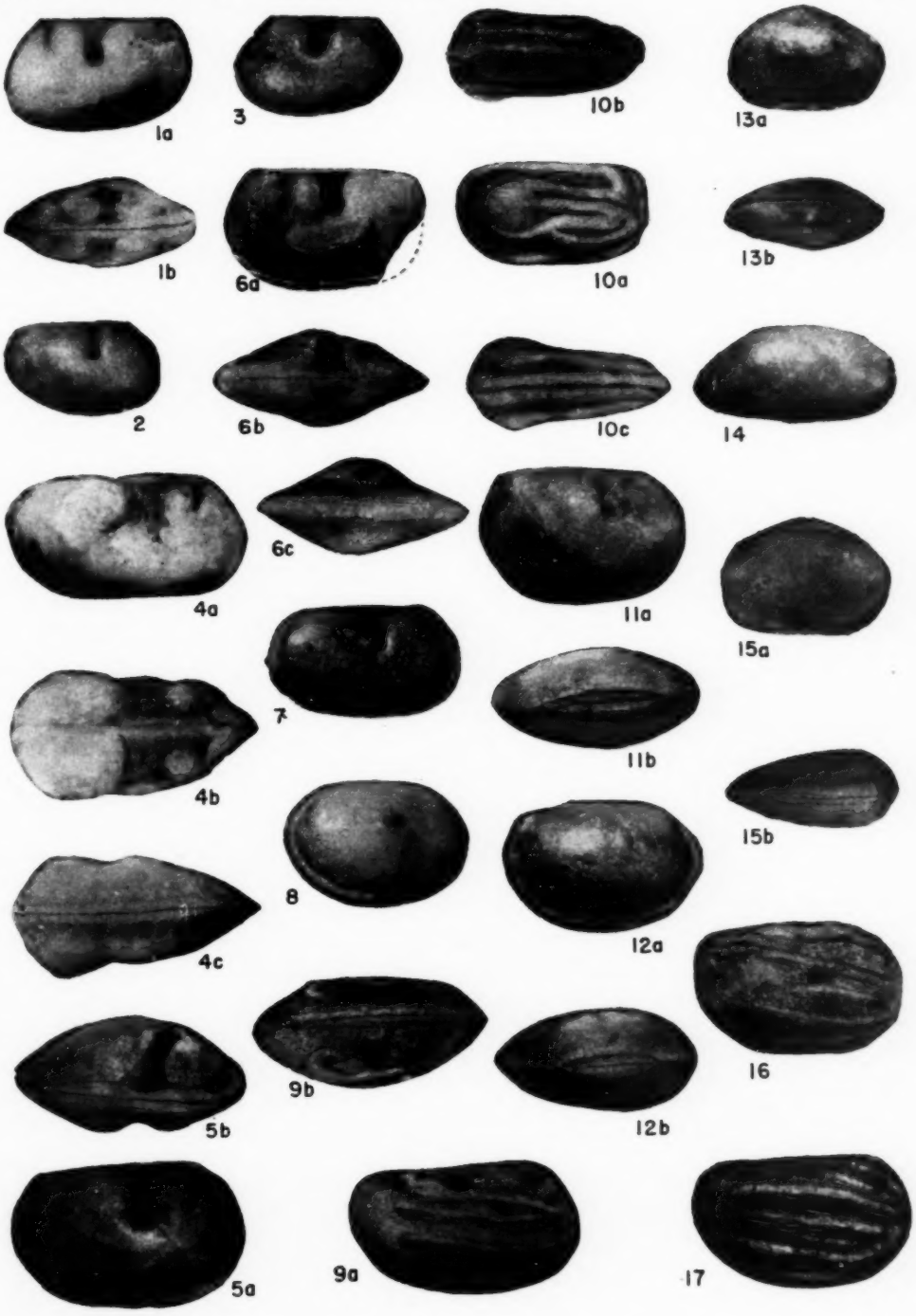
Plate 26, figure 14

Carapace elongate; dorsum broadly and gently arched, somewhat flattened centrally; venter straight; greatest length one fourth the height from ventral margin; greatest height one quarter of the length from the anterior extremity; anterior broadly rounded; posterior more sharply rounded; carapace smooth.

This species is distinguished from all

EXPLANATION OF PLATE 26

FIGS. *1a, b—Jonesina odini* Coryell and Johnson, n. sp. *a*, Right and *b*, dorsal views, ×35. (p. 215)
2—Kloedenella sigurdi Coryell and Johnson, n. sp. Left valve, ×35. (p. 215)
3—Jonesina puncta Morey. Right valve. (p. 214)
4a–c—Berychiopsis brynhildae Coryell and Johnson, n. sp. *a*, Right, *b*, dorsal and *c*, ventral views, ×35. (p. 215)
5a, b—Kloedenellina heimdalli Coryell and Johnson, n. g., n. sp. *a*, Right and *b*, dorsal views, ×35. (p. 216)
6a–c—Lokius sigynae Coryell and Johnson, n. g., n. sp. *a*, Left, *b*, dorsal, and *c*, ventral views, ×40. (p. 216)
7—Gillina vitharri Coryell and Johnson, n. g., n. sp. Right valve, ×40. (p. 217)
8—Reversabella njorthi Coryell and Johnson, n. g., n. sp. Right valve, ×35. (p. 221)
9a, b—Ceratopleurina mimiri Coryell and Johnson, n. g., n. sp. *a*, Right and *b*, dorsal view, ×45. (p. 221)
10a–c—Glyptopleurites tyri Coryell and Johnson, n. g., n. sp. *a*, Right, *b*, dorsal, and *c*, ventral views, ×40. (p. 219)
11a, b—Sansabella gunnari Coryell and Johnson, n. sp. *a*, Right and *b*, dorsal views, ×40. (p. 220)
12a, b—Reversabella reversa (Morey). *a*, Right and *b*, dorsal views. (p. 221)
13a, b—Bythocypris ulli Coryell and Johnson, n. sp. *a*, Right and *b*, dorsal views, ×35. (p. 222)
14—Macrocypris reginni Coryell and Johnson, n. sp. Right valve, ×40. (p. 222)
15a, b—Cavellina hoeniri Coryell and Johnson, n. sp. *a*, Left and *b*, dorsal views, ×35. (p. 223)
16—Glyptopleura sagae Coryell and Johnson, n. sp. Right valve, ×40. (p. 219)
17—Glyptopleura freyjae Coryell and Johnson, n. sp. Right valve, ×40. (p. 219)



Coryell and Johnson, Mississippian Ostracoda

UNIV. OF MICH.

the described Carboniferous forms by the rounded posterior extremity.

The name is derived from Reginn, a treacherous dwarfsmith of the Volsunga saga.

Length, 0.77 mm, height, 0.37 mm.

Holotype.—Columbia University micropaleontological collections.

Family CYTHERELLIDAE Sars, 1865

Genus CAVELLINA Coryell, 1928

CAVELLINA HOENIRI

Coryell and Johnson, n. sp.

Plate 26, figures 15a, b

Carapace small, subreniform, inequivalved; right valve the larger and overlapping the left except anteriorly; dorsum broadly arched with angulated apex at about midlength; venter nearly straight with slight concavity in the anterior one half; anterior broadly rounded with the greatest extremity below midheight, merging gently into the dorsum and somewhat more sharply into the venter; posterior broadly rounded with the greatest extremity about central, more gently arcuate dorsally than ventrally; greatest thickness lies in the posterior one fourth, carapace smooth. Dorsal view cuneate with evenly rounded posterior.

The name is derived from Hoenir, one of the Aesir.

Length, 0.65 mm, height, 0.41 mm, thickness, 0.30 mm.

Holotype.—Columbia University micropaleontological collections.

CAVELLINA ITHUNNAE

Coryell and Johnson, n. sp.

Plate 25, figure 8a, b, c.

Carapace subovate, inequivalved, right valve the larger and overlapping the left conspicuously dorsally and ventrally and less so posteriorly; dorsum broadly arched with the apex at about midlength; venter gently convex; anterior broadly and evenly rounded; posterior rounded into dorsum and obliquely truncated ventrally. Greatest length about median; greatest height central; greatest thickness in the posterior quarter. Dorsal view cuneate.

The name is derived from Ithunn, the goddess who had charge of the golden apples of youth.

Remarks.—This species is closely akin to *C. pulchella* Coryell and *C. expansa* Bradfield; it differs from the former in the more posterior position of the greatest height, and from the latter in the stronger overlap and the lack of angulation at the point of posterior truncation.

Length, 1.07 mm, height, 0.68 mm, thickness, 0.45 mm.

Holotype.—Columbia University micropaleontological collections.

Genus SARGENTINA

Coryell and Johnson, n. gen.

Suboval to subrhomboidal, inequivalved Ostracoda with the right valve larger and overlapping the left all around; hinge straight; dorsum arcuate or slightly sinuate; valves with a single dimple drawn out into a distinct sulcus in the dorsal half.

Genotype, *Sargentina allani* Coryell and Johnson, n. sp.

Remarks.—This genus differs from *Sansabella* by the character of the dorsal overlap and the lack of any channelling, and from *Cytherella* by the nearly straight hinge and the dimpled sinus.

This genus in named in honor of Allen C. Sargent of Graniteville, Mass.

SARGENTINA ALLANI

Coryell and Johnson, n. sp.

Plate 25, figure 9a, b, c.

Carapace suboval, inequivalved; right valve larger and overlapping the left on all margins; hingeline nearly straight, surmounted by the gently arcuate dorsum of the right valve; anterior obliquely rounded with obtuse cardinal angle and with greatest extremity below midheight; posterior rounded with greatest extremity slightly above midheight; venter gently convex; greatest length about median; greatest height under the anterior cardinal angle; left valve strongly convex, right valve less convex; each valve marked in the dorsal half, just in front of midlength, by a very deep dimple produced dorsally into a distinct sulcus. Dorsal view lobate with tapered ends.

Length, 0.91 mm, height, 0.63 mm, thickness, 0.40 mm.

Holotype.—Columbia University micropaleontological collections.

SARGENTINA FORSETII
Coryell and Johnson, n. sp.

Plate 25, figures 10a, b, c

Carapace suboval, inequivalved; right valve the larger and overlapping the left on all margins; hingeline straight, surmounted by the somewhat sinuate dorsum, which is flattened posteriorly and convex anteriorly; anterior margin obliquely rounded with the greatest extremity below midheight; posterior rounded with the greatest extremity above midheight; venter flattened centrally, rounding into the ends; the convexity of the anterior half of the left valve is much stronger than that of the right; posterior half of the carapace strongly inflated; the dorsal half of each valve, just in front of midlength is marked by a deep elongate dimple produced dorsally into a prominent sulcus.

The name is derived from Forseti, the god of justice.

This species differs from *S. allani* Coryell and Johnson, n. sp., by the strongly inflated posterior, curvature of post-ventral margin, and cuneate dorsal view.

Length, 0.95 mm, height, 0.60 mm, thickness, 0.50 mm.

Holotype.—Columbia University micropaleontological collections.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 225–227, 2 TEXT FIGS., MARCH, 1939

A SIMPLE APPARATUS FOR SORTING MICROFOSSILS[1]

ADOLF FRANKE

IT IS the purpose of this paper to describe an easily constructed sorting apparatus of simple design, use of which will facilitate the rapid sorting of fine particles. Separation of microfossils from a clay or shale matrix is often both time-consuming and burdensome. Although use of carbon tetrachloride (Franke, 1930) permits a ready segregation of microfossils from most Recent and Tertiary sands, this treatment is generally of little value in the case of Cretaceous and Jurassic sediments, from which it is necessary to pick out the fossils. This operation may be aided greatly by use of a simple sorting tray, which anyone with moderate skill in handicraft can make for himself. It may be employed for sorting bryozoans, minute mollusk shells, minerals, or any other small dry objects.

The apparatus consists of a platform designed to hold a receiving tray or watch glass, over which a tin box lid containing material to be sorted may be placed. Needed for construction of the platform are: (1) a rectangular piece of cardboard, about 105 mm wide, 125 mm long, and 0.5 to 1.0 mm thick; (2) a wooden board of the same width and length as the cardboard but about 5 mm thick, to serve as holder for the microfossil receiving trays (Franke, 1935), or, if a watch glass of 30 to 40 mm diameter is used, the board must be 0.5 to 1.0 mm thicker than the height of the glass; (3) three strips of wood from a cigar box, 3.5 to 4.0 mm thick, 12 mm wide, and 100 mm long; and (4) several small nails or tacks.

Draw lines on the card and wooden board through the center and bisecting each side. If the apparatus is to be adapted for use with transmitted light, employing transparent receptacles like those of von Scheffen (1934, 1937), a circle with diameter of 16 mm should be drawn around the midpoint of the cardboard. If one adopts as containers for the sorted material, the pasteboard slides with center depressions, the slides measuring 26 by 76 mm or 28 by 48 mm, these are placed so that the long and short sides of the slide correspond to those of the board and with the center of the slide exactly above that of the board; then the outline of the slide is drawn on the board. If one chooses a watch glass as container for the sorted material, a square with sides 1 mm longer than the diameter of the crystal should be drawn about the center point of the board. A semicircular cut-out at the end of the space for the slide or at one side of the square space aids in removal of the receptacle from the board enclosing it. Figure 1 shows the platform arranged for a slide 26 by 76 mm. The space for the slide and the cavity to aid placement and removal of the slide should be cut from the board with a small hack-saw, and then the cardboard is fitted to the wooden board and nailed or tacked in place. Fastening with glue is not recommended, for the boards may easily warp. Now draw lines to mark the inner edges of the three strips, one for the end strip parallel to the short side of the board 25 mm from the edge opposite the semicircular cut-out for removal of the slide (in the case of the 26 by 76 mm slide, coinciding with one end of the space for the slide), and two for the guide strips on the sides, these lines being parallel to the longer sides of the board 38 mm distant from the midline. Nail the strips in place. The area enclosed by the strips is used for sliding the tin box cover to be described.

The upper part of the apparatus consists of a flat metal jar cover 75 mm in diameter with a rim 7 mm high, which serves to hold material for sorting. The lid of a cold cream jar, for example, of the size indicated may be used. The lacquered surface may be removed easily by boiling in a sodium carbonate solution. A hole 4 to 5 mm in diameter is punched through the center of the lid from the outer side, the up-bent rim being directed inward. This rim prevents accidental escape of materials placed in the lid for sorting. The inner side of the lid should be painted black with lacquer, or roughened and covered with a round piece

[1] Translated from German manuscript by Raymond C. Moore.

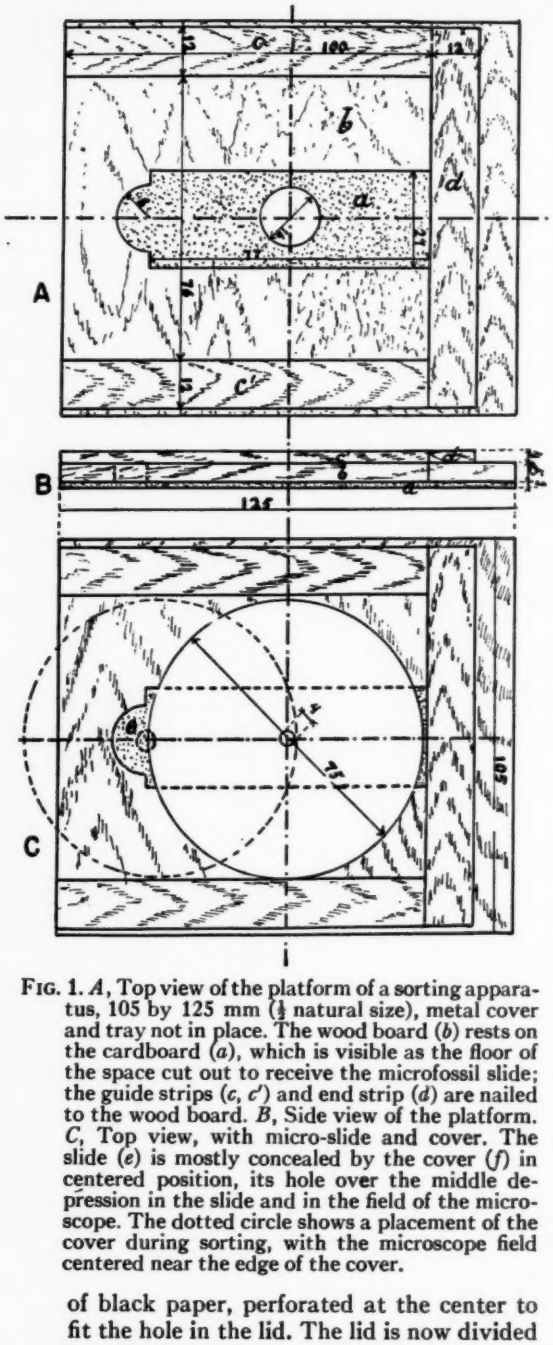

FIG. 1. *A*, Top view of the platform of a sorting apparatus, 105 by 125 mm (½ natural size), metal cover and tray not in place. The wood board (*b*) rests on the cardboard (*a*), which is visible as the floor of the space cut out to receive the microfossil slide; the guide strips (*c*, *c'*) and end strip (*d*) are nailed to the wood board. *B*, Side view of the platform. *C*, Top view, with micro-slide and cover. The slide (*e*) is mostly concealed by the cover (*f*) in centered position, its hole over the middle depression in the slide and in the field of the microscope. The dotted circle shows a placement of the cover during sorting, with the microscope field centered near the edge of the cover.

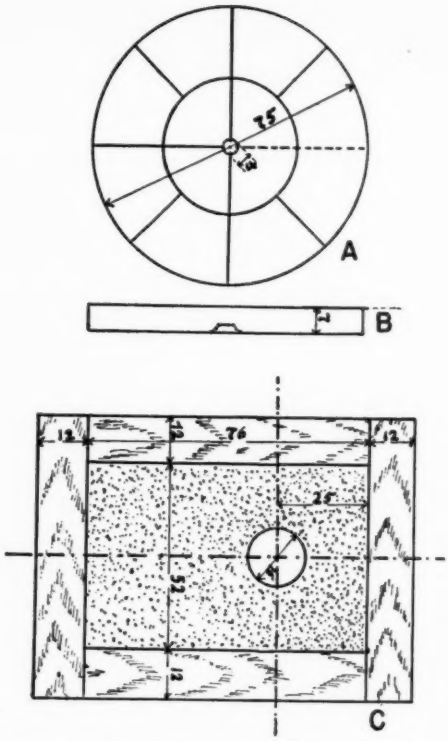

FIG. 2. *A*, Metal cover of sorting apparatus in plan; the inside covered with black lacquer or black paper divided into fields by white lines in the manner shown by the black lines of the drawing, one radius dotted to mark place of beginning work of sorting. *B*, The cover in side view; the central hole with upturned rim being indicated. *C*, Container made of cardboard and four wood strips, for placement between the guide strips of the platform of sorting apparatus; the metal cover belonging to this has a diameter of 50 mm and a central hole 2 or 3 mm in diameter.

of black paper, perforated at the center to fit the hole in the lid. The lid is now divided into fields by drawing (with white ink on the black paper or white lacquer on the black lacquer) a circle, four radii and four half radii (Fig. 2A). If paper is used, after it is pasted down and dried, it should be covered with transparent lacquer or shellac.

The metal cover is placed between the two guide strips and against the end strip, the apparatus being placed on the stage of the microscope so that at low magnification the hole in the cover occupies the center of the field. Strips should then be attached to the under surface of the apparatus at the sides of the microscope stage so that it will be fastened to the stage. In addition, a piece of wood may be attached to the appa-

ratus to fit against the column of the microscope. In this manner the apparatus may be centered exactly in the optical axis. If, as in the case of binoculars, a stage is lacking and the feet are spread, a box with open back and front may be made, the sides of such height that the feet may be pushed inside to rest on the bottom of the box; the sorting apparatus is then placed on top. The microscope must be so placed that the hole in the sorting tray lies in its optical axis.

Manipulation of the apparatus is very simple. Material to be sorted is strewn in the metal lid, space near its edges being left relatively free because objects there are less readily picked up with needle or brush. The lid is pushed and turned between the guide strips so as to bring each section of its surface into the microscope field of view. The waxed point of a needle in a wooden handle may be used to pick up objects, which adhere to the wax. Holding the needle in the right hand so that the object remains in the field of view, the metal cover is pushed with the left hand against the end strip bringing the central hole into the field of vision, and the object is dislodged on its rim so as to fall into the container below. In this way objects cannot be lost as was easily possible in older methods of sorting.

In the case of very rich material or when one wishes to segregate individual species from this or already sorted material, use is recommended of a container that is placed between the guide strips and the end strip. This container has a base and a metal lid 50 mm in diameter, with a rim 6 mm high. The base consists of a rectangular piece of cardboard 76 by 100 mm and about 0.5 mm thick, four strips 76 mm long, 12 mm wide, and 3.5 mm thick. A longitudinal midline is drawn on the cardboard, and a cross line at a distance of 37 mm from one of the ends; a hole 16 mm in diameter is cut where these lines cross. The four strips are nailed as shown in figure 2C. This container must fit the area between the guide strips and end strip of the sorting apparatus. The metal lid, 50 mm in diameter, belonging to the container, must first be cleaned of lacquer as described above, and a center hole punched like that in the larger cover, but with diameter of only 2 or 3 mm. It should be prepared and divided into fields as was the large lid. Scheffen's transparent cells are especially suitable for use with this container, and they also are adapted for segregating into individual cells selected but unsorted objects.

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Adolf Franke, Arnstadt, Thüringen, Deutschand. Manuscript transmitted by Helen Jeanne Plummer to the Editor, June 15, 1938.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 2, PP. 228–229, 1 TEXT FIG., MARCH, 1939

PLATYCRINID COLUMNALS IN LOWER PERMIAN LIMESTONE OF WESTERN TEXAS

RAYMOND C. MOORE

STEM segments of crinoids belonging to species of *Platycrinites* Miller (long but erroneously called *Platycrinus* by authors), *Eucladocrinus* Meek, and *Camptocrinus* Wachsmuth and Springer are characterized generally by an elliptical outline of the articulating surfaces. In most cases the proximal columnals, next to the dorsal cup, are circular. Also, several species of *Platycrinites* have stems that are circular in cross section throughout their length. The peculiarity of elliptical shape, however, accompanied by rotation in position of the long axis so as to give a twisted appearance in stems of the first two genera mentioned, is properly associated with these crinoids. The stem of *Camptocrinus* is coiled in a plane but not twisted, and the segments are commonly distinguishable by the nature of cirri markings. *Platycrinites* and *Eucladocrinus* belong to the family Platycrinitidae and *Camptocrinus* to the family Hexacrinidae. All are camerates, and until recent years were thought to be restricted to Lower Carboniferous rocks.

Wanner, in 1916 (p. 53) reported occurrence of *Platycrinites* in Permian rocks of Timor, and he described other platycrinids assigned to *Pleurocrinus* Austin and Austin, and new genera called *Eutelecrinus* and *Neoplatycrinus*. Additional Permian representatives of these genera, and also of *Camptocrinus*, were described by Wanner in 1924 (pp. 75–81) and 1937 (pp. 67–88), the latter work containing definition of another new platycrinid genus, *Plesiocrinus*. All of Wanner's material consists of dorsal cups, no specimens of columnals being reported. The stem segments belonging to these Permian crinoids may be elliptical, or round, or both.

The occurrence of *Platycrinites* in Upper Carboniferous rocks of China was assumed definitely by Tien (1926, p. 43) when he discovered strongly elliptical crinoid columnals, but no dorsal cups, in the Houkou limestone. These columnals are certainly unlike any of those known to represent *Camptocrinus*, but they could readily belong to *Eucladocrinus* or possibly to one or more of the platycrinid genera described from the Permian of Timor.

Weller (1930) has described seven types of elliptical columnals from lower Pennsylvanian beds (Des Moines series) found at a locality in Warren County, Indiana. Probably because the well marked fulcral ridges on these segments indicate slight to strong rotation of the stem, he assigned them to *Platycrinites*. This overlooks possibility that they may belong to *Eucladocrinus* or some other platycrinid genus.

Wright (1937, p. 396, pl. 15, figs. 2–9, 11, 12, 14) has recorded a species of *Camptocrinus*, represented by dorsal cup and stem fragments, from the upper part of Lower Carboniferous beds in Scotland. The appearance of the elliptical columnals differs from that of platycrinid genera.

In a recent paper (Moore, 1939, p. 195) devoted to the problem of classification and nomenclature of dissociated crinoidal remains, I have described some elliptical columnals from lower beds of the Missouri series of southern Kansas. These evidently belong to a platycrinid, but because identification in terms of described crinoid genera is deemed uncertain or impossible, these columnals were placed in the "form genus" or group called *Ellipsellipsopa*, and given a subdivisional or section name *spicata*. This particular type of elliptical stem segment can thus be designated binominally and recorded as to stratigraphic horizon and locality without commitment concerning the genus of crinoid represented.

Discovery of unusually large, highly elliptical crinoid columnals in Lower Permian rocks of western Texas is worthy of record, for this furnishes indication that a robust species of platycrinid was existent in North America in Permian time. The specimens described were sent to me by Mr. John Skinner, of the Humble Oil and Refining Company, Midland, Texas. They came

from limestone of Wolfcamp age (zone of *Pseudoschwagerina*, *Properrinites* and *Artinskia*), in Sutton County, Texas.

ELLIPSELLIPSOPA LATISSIMA Moore

Text figure 1

Extremely wide, laterally compressed columnals with a small, centrally located elliptical lumen that is bordered by a raised lip. The fulcral ridge occupies the medial portion of the articular face in the line of the long axis, being most strongly elevated at points about half way between the lumen and the extremities; the crest of the ridge forms a straight line, variation in height being due to excavation of the articular face. The fulcral ridge widens slightly towards the lateral extremities, and this part is marked

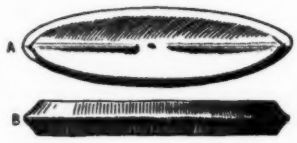

FIG. 1.—*Ellipsellipsopa latissima* Moore, Wolfcamp formation, Sutton County, Texas. *A*, Articular surface of a segment, ×1; *B*, side view showing length of segment and keel, ×1.

by a double row of fine denticles. The outer, nonarticular surface of the columnals carries a low, narrowly rounded ridge that girdles the midlength of the segment; surface otherwise smooth; no marks of cirri attachment on three contiguous columnals.

Extreme width in the direction of the fulcral ridge and reduced width at right angles to the ridge produce an exaggerated ellipticity of form that distinguishes these columnals. The long axis of the ellipse is more than four times as great as the short axis. The extremities of the articulating faces are pointed, not evenly rounded. The large size of the ossicles is also noteworthy. Measurements of a typical segment are as follows: width of articular face along the long axis, 32.5 mm, along short axis, 7.6 mm; greatest width of segment, 35.1 mm; length of segment, 4.0 mm; diameter of lumen, long, 1.0 mm, short, 0.4 mm; maximum depth of articular face below summit of fulcral ridge, 1.1 mm.

Remarks.—Judging from available illustrations, the only known platycrinid stem that approaches the one here described in highly compressed form belongs to *Eucladocrinus pleurovimenus* (White), from the Burlington limestone, lower Mississippian, of Iowa and Missouri, but figures showing the shape of articular faces are not given; the sides of the stem segments of *E. pleurovimenus* are smooth and straight, not keeled. One of the columnals identified as "*Platycrinus* sp." by Tien (1926, pl. 3, fig. 5b) is strongly compressed, the long axis being three times as great as the short one, but the extremities are distinctly more rounded than in *E. latissima* and the sides of the segments are not keeled. The most highly elliptical columnal figured by Weller (1930, text fig. 1) has a long axis that is only twice as great as the short one.

Occurrence.—Wolfcamp formation, Lower Permian; inlier on Epps Creek, Sutton County, Texas.

Types.—Syntypes in collection of Humble Oil and Refining Company, Midland, Texas. Plastotypes, University of Kansas, no. O-60471.

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REVIEWS

HANDBUCH DER PALÄOZOOLOGIE, edited by O. H. Schindewolf. Band 6, 1: GASTROPODA by W. Wenz. Berlin; Gebrüder Borntraeger, 1938.

It is now some 25 years since the appearance of the last edition of Zittel-Eastman's *Text-Book of Paleontology*, and 14 years since the sixth and last edition of Zittel's *Grundzüge der Paläontologie*. Zittel's great *Handbuch der Paläontologie*, the fundamental compilation of information on which all of these rested, began to appear in 1876, over 60 years ago, and was completed a few years later. While the editors of the various editions of the *Text-Book* and of the *Grundzüge* have made valiant efforts to keep abreast of the times, their volumes are essentially condensations, and have inevitably dropped behind for the lack of a new and up-to-date compilation of fundamental data of the scope of the original *Handbuch*. This the new *Handbuch der Paläozoologie* is intended to supply. The work is appearing under the competent editorship of Prof. O. H. Schindewolf, of Berlin, and the different zoological groups are to be treated by specialists from several countries, each writing in his own language. The plan calls for twenty volumes, as compared with the five that was ample 50 or 60 years ago, when Zittel was compiling his *Handbuch der Paläontologie* of similar scope. The necessity for a comprehensive work of this sort to assemble the results of research of the past 50 years has been so very evident to workers in paleontology for some time that it calls for no special comment here.

The first-issued part of this much needed work is the *lieferung* containing the first 15 signatures of volume 6, section 1, dealing with the Gastropoda. A second *lieferung* of 15 signatures of the section on the Gastropoda has recently come to hand. The section on the Gastropoda, which will be made up of some 10 or 11 *lieferungen*, is the work of Doctor Wilhelm Wenz, of Frankfort-am-Main. Doctor Wenz, a former pupil of the late Professor Ernst Koken, has himself been a leading worker in the field of Tertiary land and fresh water gastropods for many years. Thus, through his early training with the great student of Paleozoic and early Mesozoic gastropods, and through his own work with the later and more advanced types, he is uniquely fitted to survey the whole field. It is impossible, of course, to present now a review of the entire work, but the two parts that have appeared, containing the general introductory matter and about one third of the treatment of the Prosobranchia, permit an estimate of the character of the whole. The virtue of timeliness of a brief review at this juncture may well offset the defect that the work reviewed is far from completed.

The introductory discussion occupies 84 pages of the first *lieferung*. Following a brief diagnosis of the Class Gastropoda are 16 pages devoted to the description of gastropod morphology and anatomy. This discussion includes a brief but adequate consideration of the soft parts and the lingual dentition of gastropods, matters of which every paleozoologist should have a thorough grasp, even though he never meets with them in his fossil specimens. Next, the minute structure of the shell is considered, and I think this might well have been expanded beyond the single page devoted to it. The following 7 pages are devoted to a discussion of the gross characters of the gastropod shell and its peculiarities.

The subject of gastropod ontogeny is given only one page,—again a too brief treatment of a highly significant subject. One need not be a blind follower of Haekel to feel that the torsion that occurs in the embryonic development of the gastropod is of at least enough significance to warrant brief mention in so comprehensive a work as this. Gastropod physiology next receives consideration in 2.5 pages, quite sufficient for the purpose.

The general subject of Ecology is treated in 35 pages under subheads of Habitat, Symbiosis, Biocoenosis and Thanatocoenosis, Adaptations, Distribution in Space, and Distribution in Time. The matter of distribution, especially distribution in time, is of prime importance to paleontologists, and the subject is thoroughly and carefully

treated not only in discussion but in several tables.

The subject of Phylogeny of the gastropods occupies the next 15 pages, and the treatment will prove of great interest to students of evolution of the Gastropoda. The possible derivations of each superfamily are considered, and in some cases the phylogeny within the superfamily. A number of new ideas are suggested, not the least interesting of which is that members of the superfamily *Tryblidiacea* (new), which have symmetrical, cap-shaped shells and paired muscle scars, suggesting the segmentation of the Amphineura, may be representatives of the hitherto wholly hypothetical primitive gastropod with bilateral symmetry of the soft as well as the hard parts. It seems to me that some circumstances oppose this idea, but it is a very fertile concept that quite possibly may be true. The section on phylogeny will prove to be one of very considerable interest to the nonspecialist who is interested in evolution.

Next appears very brief announcement of the taxonomic outline to be employed, giving subclasses, orders, and suborders. The class Gastropoda is subdivided as follows:

1. Subclass Prosobranchia
   1. Order Archaeogastropoda
   2. Order Mesogastropoda
   3. Order Neogastropoda (Stenoglossa)
2. Subclass Opisthobranchia
   1. Order Pleurocoela (Tectobranchia, Steganobranchia)
   2. Pteropoda
      1. Suborder Thecosomata
      2. Suborder Gymnosomata
   3. Order Sacoglossa
   4. Order Acoela
      1. Suborder Notaspidea
      2. Suborder Nudibranchia
3. Subclass Pulmonata
   1. Order Basommatophora
   2. Order Stylommatophora

Deserving of applause is Wenz's conclusion that the conulariids, tentaculitids, hyolithids, and others comprising the so-called primitive "pteropods," have nothing whatever to do with the true pteropods and are very doubtfully to be regarded as molluscs at all. I share his doubt that *Chuaria* Walcott and *Harttia* Walcott (not Steindachner) are molluscs, and am rather sorry that the former was not eliminated from further consideration along with *Harttia* Walcott and the false pteropods. One may also regret the inclusion of several other genera that are highly questionable as gastropods.

Paleontological technique receives consideration in 7 pages, under subheadings (a) Extraction and preparation of material, (b) Important general and systematic literature and (c) Nomenclature. The treatment in each case is brief but adequate for a work of this sort. Further technical matter is presented under the headings Treatment of Faunas, Description of New Species, Genera, etc., Selection of Types and Rules of Nomenclature. Doctor Wenz's approach to each of these matters is gratifyingly modern, sane, and practical, and well worth the perusal of all students of Paleontology, however remote is their interest in Gastropoda.

The general introductory matter is concluded with a classified bibliography of the works pertinent to the preceding pages. Further lists of references are to be included at the end of each volume.

The main body of the work consists of the brief diagnosis of each systematic unit of the class Gastropoda above the rank of species, viz., subclass, order, superfamily, family, subfamily, genus, and subgenus. The diagnoses of genera and subgenera are prefaced with a list of synonyms, both subjective and objective, and a citation of the genotype species; and is generally accompanied by an illustration of a species, usually the genotype.

The procedure of naming the genotype of each generic name and of illustrating most of these genotype species is a distinct and marked step in advance of the procedure of most works of similar scope and cannot be commended too highly. Examining the details of procedure more critically, one could wish that more of the genotype citations had been documented. Undocumented citations are dangerous and very difficult to check.

Doctor Wenz has displayed fine courage in breaking away from the overconservative practice of the past of trying to crowd many incongruous fossil genera into the classical families erected for living genera. He has established numerous new families, superfamilies, and subfamilies, and many

of these units, for the first time in a comprehensive work on fossil and living gastropods, begin to show some cohesion and unity. That many of his new units may not ultimately stand, and that much rearranging will be done by future workers is to be expected. Wenz has broken away from a traditional taxonomy which was notoriously unsatisfactory, but from which no one has heretofore had the temerity to deviate materially. In this he is much to be commended. Time alone can place proper valuation on his new units, but it is my opinion that a high percentage of them will be found to follow nature.

The treatment of the genera, the foundation of the entire work, is based entirely on the literature and inevitably carries with it the errors that are buried in the literature, and which can only be uncovered by independent research, an impossible task on the scale of this work. That Doctor Wenz has covered the literature and covered it with amazing thoroughness is one of the factors that gives such unusual value to the work.

The illustrations are abundant, as already indicated, and rare is the unillustrated genus. The figures are half-tones, most of them reproductions of older illustrations, often rather crudely redrawn and suffering by comparison with the originals from which they were taken.

Wenz's Gastropoda is a work that should be of as great interest to the malacologist as to the paleontologist, for here we find the living genera integrated taxonomically with the known fossil genera. It is all too common for students of living forms to neglect entirely the records of the past, without which the present is incomprehensible. The work is one that no library that makes any pretence of scientific adequacy can afford to lack. To the individual worker on living or fossil gastropods who is not closely in touch with an adequate library, the work will be a gold mine of useful information.

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Handbuch der Paläozoologie, O. H. Schindewolf editor, Band 2D, Lief. 2: Bulman, O. M. B., *Graptolithina;* pp. 1–92, 42 text figures (each including one to 12 illustrations) Gebrüder Borntraeger, Berlin, 1938.

This paper on graptolites constitutes one of a large number to be published in 20 parts, 11 on invertebrates, 8 on vertebrates and one a summary by the editor. Part 2 on Coelenterata has been divided among six authors, the graptolite group being treated by Bulman.

In this article of nearly 100 pages, the author has given an extremely comprehensive treatment of graptolites, dividing them in customary manner into two major groups, Dendroidea and Graptoloidea.

Dendroidea.—Bulman characterizes the Denroidea as polymorphic, composed of hydrothecae, bithecae, and budding individuals assembled in plantlike colonies, and gives their range as Middle Cambrian to Carboniferous.

Under morphology the relationships of budding individuals, hydrothecae and bithecae are shown by excellent detailed enlarged drawings, tables, and serial thin cross-sections. The form, structure and significance of each of these three elements are discussed, together with methods of thecal grouping, shape of rhabdosome, mode of branching, mode of attachment, ontogeny, phylogeny, and geographical and geological distribution. Under ecology, the evidence indicates a planktonic habit, with the forms either attached to floating seaweeds, or provided with individual floating discs, in the earlier forms, while the later types give evidence of attachment to the bottom of the sea.

In the systematic division of the group he characterizes 20 genera in 4 families and 11 genera of uncertain relationship, and gives illustrations of the more characteristic types.

Graptoloidea.—In a similar manner, the other major group, the Graptoloidea, is treated in the various parts, consisting of sicula, hydrotheca, cross canals, coenosarcal canal, virgula and nema, together with the development of the variations in the form of the hydrotheca and consequent variations in the rhabdosomes, with types of branching, periderm characteristics, and the development of spines and floats. For this group he gives a shorter range of Tremadocian

(Ordovician) to Upper Silurian and possibly Devonian.

The development is treated under five important types: dichograptid, isograptid, leptograptid, diplograptid, and monograptid, and particularly clear illustrations are given to show the serial development and relations of these types. Under physiology and significance of the sicula in the life history, it is concluded that the embryo was probably produced asexually. While no evidence has yet been discovered, the reviewer is inclined to believe that there were sexual elements either in the prosiculae or in the structures which produced them, because in the sexual method of reproduction lies the most effective method of change to produce new varieties and new species. Also, Bulman states that "graptolites exhibit 'programme evolution' perhaps better than any other group of organisms." In considering the affinities of graptolites it is concluded that they fit best into a separate class of the Coelenterata. In the systematic treatment of the Graptoloidea 66 genera are characterized in 9 families, with 4 genera of uncertain relationships.

The importance of graptolites as horizon markers in specific zones is recognized, and it is stated that "In general, the graptolites permit more widespread correlation than any other organisms, at least of Lower Paleozoic age."

In a brief postscript, the recent work of Kozlowski is summarized, in which three new orders and many new genera are established, important structure of the periderm discovered, and the close relation to the Pterobranchia noted. The autothecae and bithecae are considered an expression of sexual dimorphism, and the loss of bithecae in most graptoloidea is explained as a transition to hermaphroditism. This seems to be a confirmation at least in part of the reviewer's views that graptolites had sexual reproduction.

A bibliography includes 95 authors, with a large number of papers listed for some of them.

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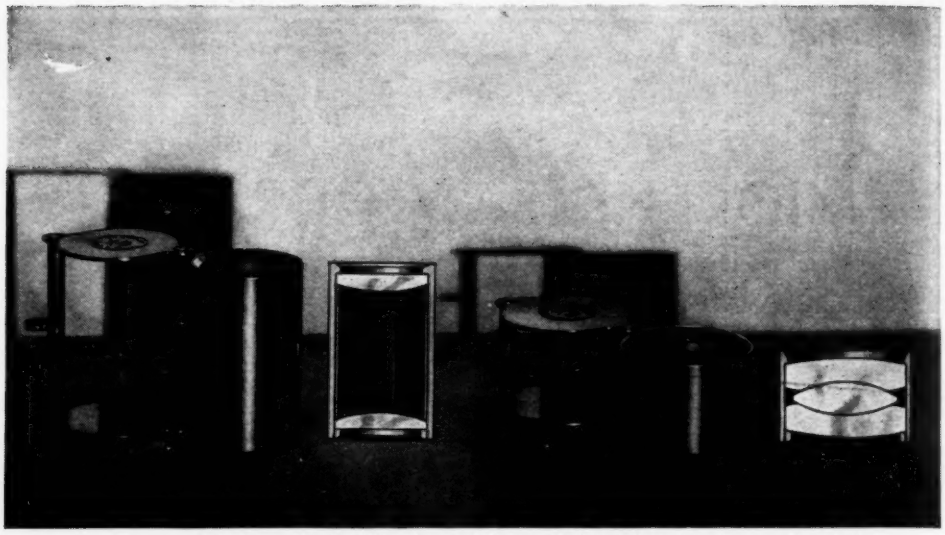

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